FINAL

Marine Fish and Benthos Studies in Knik Arm Anchorage, Alaska

Prepared for
Knik Arm Bridge and Toll Authority and
HDR Alaska, Inc.

November 30, 2005
12214-10/12214-12

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Prepared for
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HDR Alaska, Inc.

Edmonds

November 30, 2005
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MARINE FISH AND BENTHOS STUDIES
IN KNIK ARM
ANCHORAGE, ALASKA

EXECUTIVE SUMMARY

Background

Knik Arm (the Arm) is a shallow glacial estuary with extreme physical habitats characterized by large tidal ranges, strong currents, massive inputs of glacial and coastal sediment, and severe seasonal ice scour. Despite these conditions, the 1983 Knik Arm Crossing studies (Dames & Moore 1983) demonstrated a surprising level of biological activity in the Arm. The present study provides recent data and analyses of ecological conditions in the Knik Arm estuary based on sampling of fish and benthic invertebrates conducted in 2004 and 2005. This study was initiated by the Knik Arm Bridge and Toll Authority (KABATA) as part of a baseline data collection program relating to ongoing environmental analyses of the proposed Knik Arm Crossing project.

Approach

Fish and macroinvertebrates were collected by beach seine monthly from July through November 2004 and from April through July 2005. Beach seining from Point Woronzof to Fire Creek included several stations sampled during the 1983 Knik Arm Crossing studies and several new stations (Figure 1). Beach seine, otter trawl, and benthic cores were used to sample nearshore fish and benthic invertebrates.

To gain a better understanding of the ecology of the central (offshore) part of the Arm, surface tow net sampling was conducted from May through July 2005 on a series of transects across the Arm between Point Woronzof and Six Mile Creek. Sampling around Port MacKenzie facilities was conducted using a fixed tow net and a 30-foot beach seine in June and July 2005. Water quality, specifically temperature, salinity and turbidity, were recorded at all locations on all dates sampled.

Results

Water Quality

The overall picture of water quality in Knik Arm is of an area that is extremely well mixed both laterally and vertically by strong currents and vertical turbulence. An overriding water quality characteristic of Knik Arm is its high-suspended sediment load, resulting in very high turbidity and low light penetration throughout the year. However, during periods of low wave activity, and in areas lacking vertical turbulence, we frequently saw areas where a thin surface layer of 4 to 10 cm would clear somewhat. In general, there was a trend for water in the southern part of the Arm to be more saline than water to the north. Temperature was somewhat more constant throughout the Arm, but both salinity and temperature had a strong seasonal variation. Substantially cool (near freezing) temperatures occur throughout the winter until after the spring ice breakup in April. Temperature increases to a peak in July and August, and cools to near freezing in November. The opposite trend was observed for salinity.

Fish

A total of approximately 440 sets were made with all gear types, capturing approximately 7,200 fish and demonstrating a considerable presence of both juvenile and adult salmonids and other species along the beaches of Knik Arm.

120-foot Beach Seine. Beach seining was highly successful in capturing fish in shoreline areas within Knik Arm. The sampling scheme provided coverage over the entire portion of the year in which sampling by beach seine is possible within the Arm. Over the two sampling periods, 18 species of fish including 7 species of adult and juvenile salmonids were captured with the beach seine. Species composition and relative abundances were generally consistent from 2004 and 2005 with the notable exceptions of some seasonal anadromous fish migrations, such as juvenile and adult salmon and eulachon that were more abundant in the spring of 2005.

Juvenile salmon (all species combined) were the most dominant taxon within the Arm averaged over both years. In the 2004 sampling, which began after most salmon outmigrations had peaked, juvenile salmon were second in abundance to threespine stickleback, however, in 2005 when sampling began in April, salmon were collectively more abundant than threespine stickleback. Multiple year classes of juvenile coho, sockeye, and Chinook were present in the Arm in late spring and early summer and some coho and Chinook remained in the Arm into late fall. Only a single cohort of juvenile chum and pink salmon were present, mostly in May and June.

Adult Chinook salmon were captured in the beach seine in May and several adult coho, sockeye, pink and chum salmon captured in July of both years. Only coho were captured in August.

Among the non-salmonids, threespine stickleback was the most common single species in the study contributing over 28 percent of the total catch with strong peaks in numbers of very small fish in July and August. Two smelt species were seasonally highly abundant within the Arm: Longfin smelt had a varying but extended presence from June through October, sometimes in dominating numbers in individual sets and comprising over 13 percent of the total catch. Eulachon was only present during a relatively short period during its spawning run in May. Saffron cod had a significant presence in the Arm over much of spring, summer, fall, and early winter and contributed nearly 13 percent of the total catch.

Tow net. From May through July 2005, we added tow net sampling to investigate fish use of mid channel areas of Knik Arm and confirmed that all common species in the beach seine (including the bottom dwelling ringtail snail fish!) were present in surface waters, even in the deepest central channel of the Arm. There was no significant difference in catches from nearshore, versus central arm stations. The most abundant juvenile salmonids in our tow net catches in May and June were pinks and chums. Chinook, coho, and sockeye juvenile catch peaked in June in tow net catches.

Examination of catches in the tow net when fished offshore in June and July with catches for the same net fished from the Port MacKenzie trestle yielded some interesting comparisons. Overall, the catch rates for the two sample modes were fairly similar. In comparisons of total CPUE in the two tow net programs, chum salmon were more abundant in the offshore sampling, while coho were more abundant nearshore. Sockeye and Chinook were equally abundant in both programs. This (and the high catch of pink salmon in the offshore tow nets in May when no sampling occurred at Port MacKenzie) suggests that smaller fish (including perhaps young-of-the-year sockeye and threespine stickleback) are more likely to be entrained in the strong central Arm currents and be carried more or less passively out of the Arm with the net southerly water flow. Larger juvenile salmonids such as coho (and perhaps Chinook) may selectively be able to orient and remain along the shoreline areas, although the case for this is tenuous at best.

Growth and movement. Data from the several gear types allow some reasonable hypotheses to be made about growth and movements of juvenile salmonids and other species during the year. A single cohort of juvenile pink and chum salmon moves through the Arm relatively quickly between late April and early June. Chum and Chinook salmon are known to feed in the Arm and the catch data for all juvenile salmonid species suggest that growth is occurring.

A major movement evident in the data is the general movement of fish of most species out of the Arm as winter approaches. CPUE by month from April through July 2005 ranged from 8.2 fish (all species) per set in April to a high of nearly 20 per set in June. July values in both 2004 and 2005 were approximately 16 fish per set and stayed relatively high through October 2004. CPUE dropped sharply (to 2.5 per set) in November. While some of this decline was likely due to reduced net effectiveness under conditions of moving and shorefast ice, a majority is attributed to a general absence of fish.

Invertebrates

Invertebrates typical of shorelines in central and lower Cook Inlet are largely absent on the beaches of Knik Arm. Only three species of intertidal animals have been found: one polychaete that was fairly widespread; one bivalve with very limited distribution; and one snail that was only found at Point Woronzof.

Density of invertebrates (mostly amphipods, mysids, and crangonids) taken in the beach seine was very low in late fall and early spring but increased steadily during the open water season, remaining high from August through October. These same species also dominated in the surface tow net samples showing that the high degree of turbulence in the Arm brings these, mostly typically bottom dwelling species up to the surface.

Knik Arm Ecological Conditions

A major concern surrounding proposals to build structures along the shorelines of Knik Arm is the effect on such structures on shoreline habitat and habitat functions, especially for rearing and migration of juvenile salmonids. Physical conditions that shape the environment of the Arm and the nature and quality of habitat provided for animals living within the Arm for all or a part of their life history include: extreme tides and currents, high turbidity and suspended sediment, seasonal icing, and fluctuating salinity.

These physical conditions create unique habitat conditions and have a strong influence on the nature of the ecological habitats and processes that can occur in Knik Arm. Many of the generalizations common to littoral habitat functions in other parts of Southcentral Alaska are partially or totally inapplicable in Knik Arm. For example, the Arm has been documented or can be hypothesized to have low benthic and water column primary productivity, low to moderate density of epibenthic and pelagic invertebrates, and few invertebrates of a size that could be prey for juvenile salmonids.

The extreme turbidity and poor visibility in the Arm must severely limit the success of visual feeding by fish in all but a small portion of the total habitat present. Limited available stomach content analyses of fish species found in the Arm show a considerable level of feeding but a high proportion of terrestrial insects in stomachs examined. Anecdotal observations suggest that, despite the generally high levels of turbidity, visual feeding may be possible in microhabitats within the surficial water where short periods (minutes) of relative quiescence in the generally turbulent water allow partial clearing. We hypothesize that juvenile salmonids also can feed in these small lenses of clearer waters where prey can be seen. From our observations, it appears that these areas can occur along shorelines as well as in the middle of the Arm.

Tow net sampling showed substantial presence of juvenile salmonids in the open waters of Knik Arm. Our data and those of Moulton (1997) in offshore surface waters of upper Cook Inlet south of Fire Island, suggest that these fish, at least, were not favoring shorelines. Many of the fish, including many small individuals (e.g., chum, pink, and sockeye salmon less than 50 mm in length) appeared to have very full stomachs.

High turbidity in Knik Arm also may limit schooling by juvenile salmonids and by other normally schooling fish such as herring and smelt. Distribution of catches and general observations do not suggest schooling occurs in the Arm. Visual cues necessary for schooling are generally lacking and there is little need for the protection provided by schooling, since there are few visual predators on them (e.g., few if any avian predators or piscivorous fish).

Available data do not show significant trends of use of the east side vs. west side of the Arm for juvenile or adult salmonids, individually or as a group. There is some evidence to show that juvenile sockeye may prefer inner portions of the Arm while in the nearshore, but distribute widely once offshore. The seasonal presence of longfin smelt was also significantly greater at outer portions of the Arm (e.g., Point Woronzof).

Most of the traditional functions of littoral habitats for nurturing of juvenile salmonids are not provided by Knik Arm shorelines. For example, shallow water and structure are not necessary as refuge from predators because there are few predators present and because predation by piscivorous birds and fish that may be present, is typically visual. While we have captured large numbers of amphipods, mysids, and crangonid shrimp at times in our beach seining, tow net data indicate that these prey types are also abundant in offshore waters, as are juvenile salmonids. The primary food base for these crustaceans is likely organic matter from the streams and marshes contributing to the Arm; that material is not selectively present on the shorelines, therefore, it appears that the crustaceans themselves are not as closely associated with beaches and shallow subtidal areas as they are in clear water areas.

Thus, at the very least, juvenile salmonids in Knik Arm are neither dependent on littoral habitats for the same reasons, nor to the same degree as they are in clear water areas of Southcentral Alaska. Tow net catches (both in open water and at the Port MacKenzie facility) suggest that smaller salmonids and threespine stickleback, at least, are swept back and forth through the Arm entrained in strong tidal currents and only a small portion of these fish are along the shorelines at any given time. Yet these fish, like those captured in beach seines along the shoreline seem able to feed successfully on the available prey.

Beluga Prey Implications

Based on extrapolations from the data from the 1983 and 2004 – 2005 sampling, the species available and most likely comprising the majority of beluga diets in Knik Arm include adult salmon, eulachon, saffron cod, and longfin smelt with a strong seasonality in the availability of each prey species.

MARINE FISH AND BENTHOS STUDIES
IN KNIK ARM
ANCHORAGE, ALASKA

1.0 INTRODUCTION

1.1 Background

Knik Arm (the Arm) is a shallow glacial estuary with extreme physical habitats characterized by large tidal ranges, strong currents, massive inputs of glacial and coastal sediment, and severe seasonal ice scour. The average exchange between high and low tide within the Arm is 25 feet (7.6 meters) with maximum ranges of up to 39 feet (11.9 meters) per tidal cycle. Tidal currents in excess of 6.6 knots (3.4 meters per second) have been documented (Britch 1976). Several glacial rivers contribute high quantities of sediment to the Arm as does erosion of the near continuous extent of coastal bluffs. The strong currents and high sediment inputs result in suspended sediment values ranging as high as 1,350 mg/L (Kinney et al. 1968).

The most prevalent intertidal habitats within Knik Arm in terms of area are mud and sandflats, which usually begin at the mid to lower intertidal zone. Above elevations of about +4 to +6 feet mean lower low water (MLLW), from Eagle Bay and Goose Bay southwest, intertidal substrates vary, likely reflecting the complex dynamics between silt deposition from glacial streams, strong tidal currents, winter ice, and erosion from coastal bluffs. In general, the middle and upper beaches north of the Port of Anchorage (Port) on the eastern shore and north of Point MacKenzie on the western shore consist of gravel and cobble mixes with occasional bands of sand at the high tide line and more widespread silt/clay deposits in the middle intertidal range (Photo 1). These extreme conditions result in low primary productivity on the beaches and in the water column (Bakus 1979, Dames & Moore 1983).

Despite these conditions, the 1983 Knik Arm Crossing studies (Dames & Moore 1983) demonstrated a surprising level of biological activity in the Arm. They captured 18 species of fish in the Arm, showed that essentially all species were feeding in the Arm, and that their prey consisted in part of invertebrates present in the Arm (Dames & Moore 1983). Those studies were initiated to provide data on local conditions for use in preparation of a 1984 draft environmental impact statement (EIS) for evaluation of several possible routes for constructing a bridge across the Arm. At that time, marine studies focused on the spring period of presumed use of the Arm by juvenile salmonids during their outward migration to Cook Inlet and the Gulf of Alaska.

1.2 Study and Report Objectives

This report provides data and analyses of ecological conditions in the Knik Arm estuary based on sampling of fish and benthic invertebrates during July through November 2004 and from April through July 2005. This report is an update to, and supersedes, an earlier report on the 2004 studies (Pentec 2004). This study was initiated by the Knik Arm Bridge and Toll Authority (KABATA) as part of a baseline data collection program relating to ongoing environmental analyses of the proposed Knik Arm Crossing project. Funding for port facilities sampling was provided by Port MacKenzie in partial fulfillment of the requirements of its Corps of Engineers permit number T-790412 for port expansion.

The proposed Knik Arm Crossing project has the potential to alter the physical characteristics of Knik Arm and, consequently, to affect marine biota. This study was intended to provide insight into the ecology of the Arm with particular emphasis on the local behavior and ecology of juvenile salmonids and on the potential food sources available for the Cook Inlet beluga whale (*Delphinapterus leucas*) population. Beluga whales are protected under the Marine Mammal Protection Act (MMPA) and, because of low abundance, the Cook Inlet population is listed as "depleted."

The study was also intended to provide both a comparison with, and extension of similar studies conducted in 1983. The 1983 study collected fish and epibenthic samples during a 5-week period in spring (May and June) 1983 (Dames & Moore 1983). The present study sampled during periods not sampled in 1983 (i.e., summer, fall, and early winter) and included sampling when possible (i.e., when ice conditions allowed) over a 13-month period from July 2004 through July 2005.

2.0 METHODS

2.1 Sampling Periods and Locations

Fish and macroinvertebrates were collected with various gear types monthly from July through November 2004 and from April through July 2005, except that two surveys were conducted in May 2005. Station locations and dates sampled with each gear type are presented on Figures 1 through 3 and in Table 1. Water quality, specifically temperature, salinity, and turbidity, were recorded at all locations on all dates sampled. Beach seine, otter trawl, and benthic cores were used to sample nearshore fish and benthic invertebrates. To gain a better understanding of the ecology of the central (offshore) part of the Arm, tow net sampling was conducted from May through July 2005. Sampling around Port

MacKenzie facilities was conducted using a fixed tow net and a 30-foot beach seine in June and July 2005.

The selection of beach seining stations was based on discussions with KABATA/HDR Alaska, Inc. and on the location of stations sampled in 1983. As a result, sampling included several stations identified during the 1983 Knik Arm Crossing studies (Dames & Moore 1983) and several new stations (Figure 1). The station numbering protocol of that earlier study was preserved with even numbered stations on the west shore of the Arm and odd numbered stations on the east shore. Stations numbered Knik Arm (KA) 1 through KA 13 in the present study were sampled in 1983; those with numbers greater than 13, or with letters following the number were first sampled in 2004 or 2005. Eleven beach seining stations were sampled in this study. Sampling stations extended from Point Woronzof at the entrance of the Arm to Fire Creek within the inner Arm.

Six of these stations (KA 7A, KA 10, KA 11/11A, KA 13, KA 14, and KA 16) were considered to be "primary stations" and were sampled in the beach seining sampling events except in November 2004 when ice conditions limited station access. Station KA 11A was initially sampled in a separate study for the Port of Anchorage in September 2004 (Pentec 2005) and subsequently was sampled in both KABATA and Port-funded work. Data from both programs at this station, and from other KABATA stations also sampled during the same time period (Pentec 2005), are included in this report. Some stations were sampled north of a given point on flooding tides and south of the point on ebbing tides (e.g., KA 13N and KA 13S) to allow net deployment and retrieval in strong currents. These data were combined for most data analyses. Beach seine station locations are shown on Figure 1.

Tow net sampling was conducted in May, June, and July 2005 on a series of transects across the Arm between Point Woronzof and Six-Mile Creek (Figure 2). The tow net was also hung from the Port MacKenzie Pier Facility and fished passively during the stronger current exchanges in the Arm. Sampling locations on the pier and in the immediate vicinity are presented on Figure 3. Individual stations sampled, species captured, and field logistics and conditions during each field period are provided by the monthly field reports, compiled in Appendix A.

2.2 Sample Methods

2.2.1 Water Quality

Salinity, temperature, and turbidity were measured at all stations sampled, with all gear types, during each sampling effort. A YSI Model 85 was used to measure temperature and salinity, and a LaMotte portable turbidity meter model 2020 was used to measure turbidity in nephelometric turbidity units (NTU). On occasion, the ambient turbidity exceeded the limits for the meter (greater than 1,100 NTU); these data were recorded at that limit for purposes of statistical calculations.

2.2.2 120-Foot Beach Seine

To sample nearshore waters along Knik Arm shorelines (Figure 1), a standard 120-foot floating beach seine was employed. The seine measured 120 feet in length, 10 feet deep at the bag, and 3 feet deep at end of the wings. The wings were 60 feet in length with 0.375-inch bar mesh. The bag was 0.125-inch (bar) woven nylon mesh and measured 10 feet deep, by 7.5 feet long. This net design was developed to capture surface-oriented, smaller fish, especially juvenile salmonids, in shoreline areas and was similar to that used in Kink Arm in 1983 (Dames & Moore 1983). Because of the extreme turbidity in Knik Arm, this net was also successful at catching adult salmon.

Beach seine methods employed during the sampling period were similar to those used in juvenile salmon studies within many estuaries in the northeast Pacific. Exact location of beach seine sampling at each station was dependent on tidal elevations and currents, as well as (in October and November) ice conditions. Field personnel stood on the beach holding one end of a 100-foot towline while the skiff containing the net backed out, perpendicular to the beach. When the end of the line was reached, the skiff was turned 90 degrees and the seine was deployed parallel to the beach in the direction of the current. After net deployment, the boat returned to the beach while releasing the second 100-foot towline. The seine was then hand retrieved to the beach (Photo 1). The area sampled by the beach seine is ideally approximately 9,700 square feet; however in practice, widely varying currents often required that the net be walked with the current while retrieving, increasing the area sampled. Two sets were typically made at each station during each sampling event. Beach seining at most stations occurred at mid to higher tides because beach conditions at lower tidal elevations precluded successful sampling. Flooding, ebbing, and slack tides were sampled to assess potential differences in abundance during differing tidal conditions.

Upon retrieval of the seine, fish and invertebrates were removed from the net and placed in a bucket of ambient water. Fish were sorted by species in the field. Selected fish were preserved in 10 percent formalin and retained for confirmation of species identification and possible stomach content analysis. Selected larger fish (eulachon, longfin smelt, saffron cod, adult salmon) were frozen and turned over to the National Marine Fisheries Service (NMFS). NMFS will conduct a fatty acid analysis as described by Krahn et al. (2004) as part of a study to evaluate the diet of beluga whales in the inlet.

Lengths of most fish were measured and recorded in the field; however, when large numbers of the same species were captured, a representative subsample (usually at least 20 fish) was measured. Fork lengths were measured on species with homocercal (notched) caudal fins (tails) and total length was taken for all other species. Fish were retained in the bucket until after the second set, after which fish were released back into the estuary. Selected fish and all invertebrates from both sets at a given station were retained in a single container and preserved for laboratory identification and enumeration.

2.2.3 Tow Net

To sample offshore surface waters, a standard surface tow net was pulled between two vessels (e.g., Moulton 1997, Simenstad et al. 1991). The tow net was coned-shaped with a mouth opening of 200 square feet (20 by 10 feet) and mesh size grading from 3.5-inch knotted bar mesh at the mouth to 0.25-inch woven bar mesh in a zippered bag at the cod end (shown deployed in fixed configuration – see Section 2.2.5 – in Photo 2). Two 10-foot spreader bars with large floats at the top and weights at the bottom attach to the sides of the net to keep the mouth open vertically. The net was towed between two vessels (26-foot work cruiser and 18-foot skiff) to keep the net spread horizontally and to sample the undisturbed surface layer down to 10 feet in depth. At the end of each tow, one tow line was brought by the skiff over to the larger vessel, thus, closing the net opening. The skiff then dropped back to pick up a buoy attached to the net throat. The buoy line was pulled into the skiff, followed by the cod end. The bag was unzipped and contents were shaken and hand picked into a bucket to allow processing the catch.

The tow net was fished in a series of four transects across the Arm (Figure 2); each transect consisted of five stations located adjacent to either shore (as close as the net could be safely fished), in the center of the Arm, and half way between the center and each side. Additional sampling was done in the entrance to Eagle Bay and in the trough along the northeast side of Eagle Bay (Transects 5 and 6). At each station a fixed duration tow (5 minutes) was conducted. Sampling was conducted in mid-May, mid-June, and mid-July 2005.

Catch was processed as described in Section 2.2.2.

2.2.4 Otter Trawl

To sample offshore demersal (near bottom) waters, a small otter trawl with a 10-foot mouth, 1.5-inch bar mesh body tapering to a 0.25-inch bar mesh cod-end was deployed at several stations during the July 2004 sampling period. Standard tows of 5 minutes were made traveling at a rate of 1 to 3 knots faster than the surface current. The net was deployed so that it was dragging along the bottom for most of the tow. Tows were made in the direction of the current. This net and sampling approach were similar to those used in Knik Arm by Dames & Moore (1983). Sampling was conducted off Stations KA 7A, KA 10, KA 13N, and KA 14 in July 2004 (eight trawls, with considerable net damage). The net was lost on the first attempted tow in August 2004, and no trawling was included in later sampling that year. Trawling was conducted at three locations (off KA 7A, KA 10, and KA 14; Figure 1) in July 2005. Catch was processed as described in Section 2.2.2.

2.2.5 Benthos

A benthic hand corer with an area of 12.5 square inches (0.009 square meters) and a length of 6 inches was used to collect intertidal benthic samples at each station in July and August 2004 and in July 2005. Two or three benthic cores were collected at each station at about 1 foot in elevation above the water's edge. The time of collection was recorded to estimate the elevation of sample collection. Because of the generally coarse substrate in the middle and upper intertidal zones at most stations and because of the depauperate nature of Knik Arm infauna (Dames & Moore 1983), samples were taken in the finest sediment available at the elevation sampled to maximize the potential for finding infauna and to avoid filling the corer with a few cobbles. At stations with a mud or mud/clay upper zone with evidence of use by benthic polychaetes, additional replicated sampling was conducted to provide an estimate of polychaete abundance. Samples were sieved in the field through 4.0 and 1.0-mm Tyler screens and all benthic invertebrates were retained in 10 percent formalin for laboratory identification and enumeration. At least once over the study period, benthic samples were collected at both higher and lower tidal elevations at the primary stations including stations KA 7A, KA 10, KA 13, KA 14, and KA 16 (Figure 1), as well as several stations in the fill surrounding the Port MacKenzie (PM N1 and PM S1), and Port of Anchorage facilities.

2.2.6 Port MacKenzie Facilities Sampling

Sampling was conducted in June and July 2005 to evaluate fish presence around the existing fill and port facilities at Port MacKenzie on the west side of the Arm

(Figure 3). The primary gear types used were the tow net described in Section 2.2.2 and a 30-foot beach seine.

The tow net was deployed by suspending it from the Port MacKenzie trestle on pulleys and allowing it to fish passively in the ambient tidal current. (Photo 2). The net was rigged without the vertical spreader bars, but with 25-lb lead cannon balls on each side of the end of the wings. The net was fished by lifting it from a skiff with lines run through pulleys installed on the trestle rails (Photo 2). A closure line was rigged to allow field crew on the trestle to close the net quickly at the end of each set and when needed to avoid capture of drifting logs or debris. At the end of each set, the skiff crew would haul the bag into the skiff to release the catch for processing. The tow net was fished at three different positions along the trestle (Figure 3) from the inner bay (between the dock caissons and the first set of trestle support pilings) to the outer bay (last set of trestle pilings to the central T-pier support pilings). The net was hung off the south side of the trestle on ebbing tides and the north side on flooding tides.

A 30-foot beach seine was used to sample on the artificial mud shorelines created by sediment accumulations north and south of the Port MacKenzie facility, including the sheltered water area between the riprap fill and the new sediment accumulation south of the facility (Figure 3). This seine consisted of two 12-foot wings of 0.25-inch (bar) mesh with a central bag of 0.125-inch bar mesh. The bag was 6 feet deep and the wings tapered to 3 feet deep. The net was fished by extending it into the water, perpendicular to the shoreline, and walking it in an up-current direction for a distance of approximately 100 feet (Photo 3).

Catch from both gear types was processed as described in Section 2.2.1.

2.3 Laboratory Analysis

Invertebrates and fish of uncertain identity from beach seine and tow net samples collected in the field were preserved in formalin and sent to the Pentec laboratory in Edmonds, Washington, for identification and enumeration. Fish identifications were verified by Pentec staff based primarily on descriptions in Mecklenburg et al. (2002). Dr. Jeff Cordell, a researcher and invertebrate taxonomist at the University of Washington, identified reference samples of each invertebrate to species. Once a representative of each taxon sampled was identified with confidence, a laboratory technician was trained to differentiate among them. The laboratory technician then counted all invertebrates to the species level, where practicable, and recorded the results in a laboratory notebook. Some mysid shrimp, amphipods, and *Crangon* shrimp were either too small, or the samples too degraded, to be identified to species.

The laboratory supervisor confirmed identification of 80 percent of the samples to assure that the laboratory technician was identifying samples accurately. Additional quality control (QC) measures were conducted by the laboratory supervisor randomly selecting, re-sorting, and counting 30 percent of the samples. Each sample was checked on an individual basis and passed the QC process if accuracy was greater than or equal to 90 percent. If the accuracy of any individual sample was below the desired 90 percent, the laboratory technician re-sorted the five samples immediately preceding the one that failed the QC process.

2.4 Data Management and Analysis

Field and laboratory data were entered into Excel spreadsheets for calculation of catch statistics. Data entry by each individual was initially 100 percent checked by two people, one reading from the field/lab sheet and one following along on a print out of the data file. If 200 records were checked error free, subsequent checking was limited to 30 percent of additional records. Fish data were further assessed for errors (outliers) during analysis by setting limits on fields. If a field was left blank, or exceeded the maximum or minimum values, data were compared to the original data sheets. When errors were identified, all data entered by the staff member responsible were compared with the original data sheets to resolve discrepancies.

Excel was used to consolidate and sort data and to create charts and tables of fish and invertebrate catch by date, location, and tidal condition. Where multiple positions were fished at a given station (e.g., KA 11 and KA 11A) the data were generally combined for analysis. Two surveys conducted in May 2005 were also treated as replicates and combined for analysis. Catch per unit effort (CPUE) of fish caught by beach seine and tow net was calculated by station, date, and tide status by dividing the total number of each species caught by the number of sets made during the specified sampling effort. Monthly length frequency histograms were also prepared using Excel. In the length frequency diagrams in this report, the number provided in the center of an interval along the Y axis represents the end of the interval. For example, where the Y axis advances in 20-mm intervals, the bar above the number 40 represents the number of fish that measured from 21 to 40 mm.

SPSS (version 10.1; 2000) was used to perform statistical analyses of the null hypothesis (H_o) of the form:

> H_o: There is no difference in catch per unit effort of (species X) between or among (time periods, locations, tidal condition).

Null hypotheses were tested using the Kruskall-Wallis non-parametric one-way analysis of variance (Zar 2004). The Mann-Whitney U test, a non-parametric ANOVA for two independent groups, was used when only two groups were being evaluated. This includes a comparison between inner and outer Arm stations sampled with the pulled tow net, the inner and outer stations at Port MacKenzie, and the two months (June and July) sampled at Port MacKenzie. The results of all statistical tests were evaluated at a significance level of 0.05, with the null hypothesis rejected when $P < 0.05$.

3.0 RESULTS

3.1 Water Quality

Water temperature and salinity were measured in association with most beach seine and tow net sampling events from August 2004 through July 2005. Turbidity was also measured with most of the 2005 net sampling events. Secchi depth readings were made for part of the 2005 season but were discontinued because values were generally very low (i.e., 2 to 20 cm) and it was felt that turbidity readings provided a more reliable measure of suspended sediment load.

Turbidity was generally very high (April to July mean >250 NTU at all stations; Table 2A). Highest mean turbidity was measured in the upper Arm (KA 7; mean of 629 ppt) and lowest means were at the entrance to the Arm at KA 13 and KA 16 (309 and 257 NTU, respectively). Some apparent temporal variation was seen in turbidity with a high monthly average during spring breakup, lowest levels in early summer (Table 2B), and increasing salinity in July. No turbidity measurements were taken in later summer sampling in 2004 but data from August and September 2005 (Pentec 2005) confirm the trend for increasing turbidity in late summer (to over 650 NTU).

Mean salinity was noticeably higher at Station KA 13 than at more northern stations (KA 1, KA 2, and KA 3; Table 2A) indicating the source of saline water from Cook Inlet and fresh water from rivers tributary to the upper Arm. Mean temperature did not show a clear geographic pattern among stations sampled consistently (KA 7 through KA 16; Figure 4; Table 2A).

Strong seasonal variation in both salinity and temperature reflect cool temperatures with little snow/ice melt immediately after the spring ice breakup in the Arm in April (Table 2B; Figure 4). Mean temperature increased approximately 6 degrees Celsius between April and May and continued to increase to a peak in July (Figure 4; note that on Figure 4 and in Table 2B, the

July data area from July 2005 only). In 2004, the temperature declined during the period from August through November reaching near freezing temperatures by the November sampling effort (0.2 degrees Celsius mean). Salinity varied inversely with temperature (Figure 4), with salinity values at a peak during the early spring and early winter sampling and a late-summer (August) low. This pattern results from the substantial freshwater input during the mid-summer months as warm air temperatures increase glacial runoff in the Knik Arm Watershed.

The overall picture of water quality in the Arm is of an area that is well mixed both laterally and vertically by strong currents and vertical turbulence. That said, the suspended sediment in the Arm is relatively coarse-grained and settles fairly rapidly in quiescent waters. As a result, during periods of low wave activity, we frequently saw areas where a thin surface layer, possibly of fresher water, would clear to turbidity levels of 50 NTU or less.

3.2 Existing Intertidal Habitats and Vegetation

Stations sampled are described in the following sections and located on Figure 1 Representative photos of selected stations are provided in tabbed section following the figures.

3.2.1 KA 1 – West of Fire Creek

Station KA 1 was located adjacent to a relatively steep but densely vegetated bank and riparian area just west of a high marsh bench near the mouth of Fire Creek. The riparian vegetation was a mix of willow (*Salix* spp.), alder (*Alnus* sp.), birch (*Betula* sp.), and spruce (*Picea* sp.). The marsh bench was dominated by dune grass (*Elymus* sp.), silverweed (*Potentilla anserina*), arrow grass (*Triglochin maritimum*), and seaside plantain (*Plantago maritima*). The upper intertidal zone was gravel and sand with scattered clumps of marsh vegetation and sod that had eroded from the marsh bench. Arrow grass, silverweed, and salt grass (*Puccinellia* sp.) were growing in the upper mud beach mid to late summer.

3.2.2 KA 2 – North Entrance to Goose Bay

Station KA 2 was north of the north entrance to Goose Bay at the toe of eroding bluffs with limited patches of willows and alders and an occasional spruce on the slope. The upper beach (all that was visible at the time of sampling events) was gravel and cobble with scattered larger boulders.

3.2.3 KA 3 – North Entrance to Eagle Bay

Station KA 3 was placed north of the north entrance to Eagle Bay at the toe of eroding bluffs with limited patches of willows and alders and an occasional spruce on the slope. The upper beach was gravel and cobble with scattered larger boulders (Photo 4). A broad flat of armored gravel began at about +8 feet MLLW. Tufts of newly sprouted salt grass were present in clay patches along the upper beach in August 2004.

3.2.4 KA 5A – Eagle Bay North Shore

This station was selected for sampling during late November 2004 because it was the only place north of Cairn Point where the combination of beach slope and ice conditions allowed sampling (Photo 5). The site lay at the mouth of a small drainage ravine entering the north side of Eagle Bay. The upper beach was gravel and cobbles and the middle and lower beach was moderately sloped silt/clay. The backshore and ravine bottom and sides were relatively low gradient and heavily vegetated with spruce, birch, and cottonwood (*Populus trichocarpa*).

3.2.5 KA 6A and KA 6B – Mid Goose Bay

Station KA 6A was located immediately adjacent to the south shore of the mouth of Goose Creek on a mixed beach of angular cobbles and boulders in a matrix of sand and pebbles. Because of difficult access, the site was only sampled in June 2005 and because of the limited area where seining is possible, only the 30-foot beach seine was used. No fish were captured at this site.

Station KA 6 B was south of KA 6A and could be fished with the 120-foot seine at tides below about mean higher high water. The beach was fairly steep pebbles and sand and had scattered boulders and a substantial amount of large woody debris was scattered about (Photo 6).

3.2.6 KA 7 – South Entrance to Eagle Bay

Station KA 7 was located at the toe of eroding bluffs with patches of willows at the high tide line. The upper beach was gravel and sand with scattered larger cobbles and boulders embedded in a hard clay matrix. The middle beach had a band of fine relatively soft gray clay that extended relatively low into the intertidal zone (i.e., below +10 feet MLLW). This station had limited amounts of the green alga, *Enteromorpha linza*, as well as scattered tufts of newly sprouted salt grass, *Puccinellia* sp. in mid to late summer. Small patches of a unicellular or filamentous algal mat, possibly the yellow-green *Vaucheria* (Chrysophyta), were present growing primarily on the clay.

3.2.7 KA 7A – South of Eagle Bay

Station KA 7A was located at the toe of eroding bluffs with dense alders and willows at the high tide line (Photo 7). The upper beach was gravel and sand with scattered larger cobbles and boulders embedded in a hard clay matrix. The middle beach has a band of fine relatively soft gray clay; below the clay, another narrower band of gravel and cobbles embedded in clay met a broad sandflat at about +10 feet MLLW. This sandflat extended waterward for several hundred yards and broadened to the south in the area of station KA 7B. Intertidal vegetation was limited to small patches of a felt-like alga, possibly *Vaucheria* sp., growing on the clay, and scattered small green algae, *Enteromorpha* spp., including *E. linza* and *E. intestinalis*, mostly on cobbles. All of these plants are annuals.

3.2.8 KA 7B – Offshore Sandflat

Station 7B was located approximately offshore of Six-Mile Creek, on the outer portion of the broad sandflat that extended well offshore. The bottom consisted of hard sand with ripple marks that retained water during low tide (Photo 8). The area was only sampled in July 2004 at elevation 0 feet MLLW. No macrovegetation was present and no fish were captured.

3.2.9 KA 10 – South Entrance to Goose Bay

Station KA 10 was located at the south end of the high, eroding bluff that extends out of the south extremity of Goose Bay (Photo 9). The beach extended south in front of a lower bluff reach of shoreline with limited vegetation (willows) at the high tide line. The upper beach was gravel and sand with limited numbers of cobbles. A band of relatively hard gray clay with some eroded ridges occupied the middle beach in 2004 but in 2005 fresh sediment from the eroding bluffs created areas of a soft mix clay and gravel. The lower beach was composed of hard sand and gravel, embedded in clay, and graded into a gravel cobble flat at approximately +6 feet MLLW. Intertidal vegetation was limited to small patches of a blue-green alga growing on the clay, and scattered small green algae, *Enteromorpha* spp., mostly on cobbles. Scattered tufts of newly sprouted salt grass were also present in the upper portions of the clay bands in August 2004.

3.2.10 KA 11 and KA 11A – Cairn Point (North and South)

Station KA 11 was just north of Cairn Point at the toe of eroding bluffs with patches of willows at the high tide line. The upper beach was gravel and cobble with scattered larger boulders set in a sand and silt matrix (Photo 10). The middle beach included a narrow band of soft clay. The lower beach had several large boulders and met a broad and irregular gravel, boulder, and sand flat and reef at about +8 feet MLLW. This rocky reef extended almost due north for several hundred yards and broadened to the north. Grain size became smaller to the north, and graded into the broad sand flat that continued northeast to stations KA 7B and KA 7A.

Seining was also conducted south of Cairn Point at Station KA 11A during the same sampling period in both this and in another study (Pentec 2005). Data from north and south of the point from both studies were combined and are reported here as a single station (KA 11).

Intertidal vegetation at KA 11 was limited to small patches of blue-green algal felt growing on the clay, and scattered small green algae, *Enteromorpha* spp., including *E. linza*, mostly on cobbles. No algae were seen on the low intertidal rocky bench.

3.2.11 KA 13 – Point Woronzof

Depending on tidal currents, the beach seine was either set north (flood) or south (ebb) of Point Woronzof. In 2004, invertebrates were collected with a benthic core north of the point on an armored gravel cobble beach at the base of a high sand/gravel bluff (Photo 11). In 2005, this sampling occurred in similar substrate to the south of the point. Substrate was relatively uniform throughout the tide range at both beach seine and invertebrate sites although a small area of sand bar was present at the point at lower tidal elevations. No riparian or intertidal vegetation was present except for scattered *Enteromorpha* at low elevations south of the point

3.2.12 KA 14 – North of Port MacKenzie

Station KA 14 was approximately 1 mile north of Port MacKenzie and was at the toe of a relatively stable bluff with substantial vegetation (willows, alder, and cottonwood). The upper beach was a mix of sand and gravel with occasional large boulders. The central beach, similar to that at KA 10, had a band of relatively hard gray clay with some eroded ridges. Below this band, the lower beach face had a coarse gravel and cobble substrate that graded into an irregular cobble bench that extended several hundred yards offshore (Photo 12).

Cobble on this bench appeared to have been moved by ice into ridges and terraces that ranged in elevation from +8 to +2 feet MLLW.

Intertidal vegetation in late summer 2004 included several large (i.e., 10 by 40 feet) patches of a blue-green alga growing on a clay band (Photo 13) and scattered small green algae, *E. linza.*, mostly on cobbles but also on the clay. The cobble bench had areas of relatively dense rockweed (*Fucus gardneri*) attached to cobbles as well as areas of larger strands of *E. intestinalis* and *E. prolifera*. The rockweed (a perennial species) was mostly attached to the sides of cobbles where some protection against ice scour was provided.

3.2.13 KA 16 Point MacKenzie North

Station KA 16 was located at the toe of a high and actively eroding bluff about 1 km north of Point MacKenzie. The top of the intertidal zone included a mix of sand and gravel bands above a relatively uniform gravel beach that extended down to approximately +6 feet MLLW (Photo 14). At this elevation, the beach gradient flattened into a broad but irregular sand and mud (clay) flat that extended offshore for several hundred yards. This flat was irregular with higher harder ridges of current scoured clay interspersed with areas of lower elevation, much softer mud (Photo 15). Numerous drainage rivulets flowed across the beach at low tide. At the upper portion of the flat, just below the sloping gravel beach were two very large (approximately 14 feet high) granite boulders, the tops of which were submerged at high tide (Photo 16). The lower northeast faces of these boulders supported the highest densities of rockweed seen on a natural substrate anywhere in the Arm.

3.2.14 PM N1 through PM N4 Port MacKenzie North

A substantial area of mud beach has developed as a result of sediment accumulations extending north from the Port MacKenzie fill for several hundred meters. At higher tide levels, the beach is relatively flat, filling the apex of the right angle formed where the fill juts out from the shoreline. Roughly along the hypotenuse of the triangle formed, and at a tidal elevation of about +25 feet MLLW, the beach slope increases and grades down to the underlying pebble/ cobble hard pan beach at about MLLW. As part of the facilities sampling program, three stations PM N1 (Photo 3), PM N2, and PM N3, on this mud habitat were sampled with the 30-foot beach seine at increasing distances from Port MacKenzie (Figure 3). A fourth station, PM N4, was sampled with the same gear to the north of the mud accumulation, on a natural beach similar to that described at KA 14.

3.2.15 PM SS and PM S1 through PM S4 Port MacKenzie South

A similar area of mud beach also has developed on sediment accumulations extending south from the Port MacKenzie fill for several hundred meters. As part of the facilities sampling program, the small cove or slough between the riprap fill and the mud accumulations (PM SS; Photo 17) was sampled once with the 30-foot beach seine. Three stations PM S1, PM S2, and PM S3, on the face of the mud habitat were sampled with the 30-foot beach seine at increasing distances from Port MacKenzie (Figure 3). A fourth station, PM S4, was sampled with the same gear to the south of the mud accumulation, on a natural sandy beach that was somewhat atypical of other beaches in the Arm.

3.3 Fish

3.3.1 General

The effort expended in sampling fish in Knik Arm in 2004 and 2005 employed a variety of gear types to capture fish and associated invertebrates along shorelines and in mid-channel habitats in the Arm (Table 1). Approximately 480 sets were made with all gear types, capturing approximately 7,700 fish. Several variables were incorporated into the sample design (location, date, gear, prey base) while others (tide stage, water temperature, salinity, turbidity, and weather) were more or less randomly imposed by circumstance. For various reasons (low replication, high inherent variability in the system), the influence of several of these variables cannot be determined from the data at hand. We have focused the following discussions on the variations in fish and invertebrate abundances as functions of location and time, addressing other variables, where appropriate, in subsets of the data.

3.3.2 120-Foot Beach Seine

Beach seining was highly successful in capturing fish in shoreline areas within Knik Arm. In 2004, we made 91, 120-foot beach seine sets from mid-July to late November and in 2005 we made 179 sets between mid-April and mid-July. Although sampling occurred over extended periods in 2 years, this sampling scheme provided coverage over the entire portion of the year in which sampling by beach seine is possible within the Arm. Total catch and catch per unit effort ([CPUE], calculated as fish/set) varied over time, ranging from a high of 21.3 per set in August 2004 to a low of 2.7 per set in November 2004 (Table 3; Figure 5). (Note that on Figure 5 and on several subsequent figures, 2004 data are displayed after 2005 data to better represent the annual open water cycle of April through November.)

Over the two sample periods, 18 species of fish including 7 species of adult and juvenile salmonids were captured with the beach seine. Total catches in the two July samplings were comparable (17.2 and 18.8 fish per set in 2004 and 2005, respectively). Species composition and relative abundances also were generally consistent from 2004 and 2005 with the notable exceptions of some seasonal anadromous fish migrations, such as juvenile and adult salmon (*Oncorhynchus* spp.) and eulachon (*Thaleichthys pacificus*) that were more abundant in the spring of 2005 than in the later sampling in 2004 (Table 3).

The following sections describe the catch of individual species in greater detail during both sampling periods.

3.3.2.1 Juvenile Salmonids

In total, 167 juvenile salmonids were captured by the 120-foot beach seine during the July to November 2004 study period (Tables 4 and 5) and over 900 were collected during the April to July 2005 study period in Knik Arm (Tables 6 and 7; Figure 6). All species of juvenile and adult salmonids showed significant variation in CPUE by month sampled (Table 8), a result of their seasonal migration patterns.

Sockeye Salmon – 2004. Sockeye (*O. nerka*) were the most abundant juvenile salmonid observed during the July to November sampling period in 2004, comprising 55 percent of all juvenile salmonids captured. However, many (43 percent) of these fish came from stations KA 1 and KA 3 (Figure 1, Table 5), which were only sampled in August. Juvenile sockeye were widespread in the project area, collected at all stations except KA 5A (sampled November only), but were most abundant at stations in the inner Arm (Stations KA 1, KA 3, KA 7, and KA 10). Sockeye CPUE was highest in August, although this statement is again biased by the high catches at upper Arm stations KA 1 and KA 3. Numbers decreased sharply in September (Figure 6).

Length frequency histograms show most juvenile sockeye were between 21 and 80 mm over the whole 2004 sampling period. Examination of length frequency data over time (Figure 7) suggests steady growth through the latter half of 2004 as numbers declined in the nearshore. Most juveniles, believed to represent Age 0 fish, were between 31 and 50 mm in July, 41 and 50 mm in August, and 41 to 70 mm in September. During May and June sampling in 1983, most sockeye were between 60 and 80 mm and were likely Age 1 migrants. The very few fish under 50 mm in spring 1983 were likely Age 0 fish that correspond to the Age 0 group of 31 to 50 mm fish in July 2004. Growth in this cohort can be tracked through August and into October 2004. The groups of larger sockeye (61 mm plus range) seen in July of both years were likely Age 1 migrants that had not yet left the Arm. They were not present after August (Figure 7).

Sockeye Salmon – 2005. During the April to July 2005 sampling period, juvenile sockeye were third in abundance among salmonids behind coho and Chinook. Sockeye comprised 20.2 percent of all juvenile salmon and were captured at all stations in 2005 (Tables 6 and 7). As in 2004, sockeye was the only salmonid species to show significant variation by station (P = 0.03, Table 8) with the highest CPUE occurring at infrequently sampled upper Arm stations KA 1 and KA 6. Catch of juvenile sockeye was 40 percent higher at west side stations than at east side (Anchorage side) stations (Table 7). Few sockeye were captured in April and May with a significant peak in June followed by a slight decline in abundance in July (Table 3; Figure 6). These 2005 findings may appear to be inconsistent with the peak in sockeye abundance in August of 2004, but as reported, numerous sockeye were observed at just two inner Arm stations only sampled in August, skewing these data. Lower abundances observed in July of both years were consistent and likely reflect a lower sampling effort at inner Arm stations that were accessible only at high flood tide conditions. Significant differences in CPUE were also observed by tide stage at the time the net was set (P = 0.001, Table 8) with lowest catches during ebbing tides (Table 9).

Length frequency data show a perponderance of likely Age 0 fish between 21 and 60 mm in length with significant numbers of fish above 80 mm present in June (Figure 7). These data were consistent with 2004 data that show evidence of at least two cohorts of sockeye in the Arm through much of the open water period.

Coho Salmon – 2004. Coho salmon (*O. kisutch*) were second in juvenile salmonid abundance in 2004 comprising 25 percent of all juvenile salmonids captured and remaining present in the Arm into late November (Table 3; Figure 8). Similar to sockeye, coho were widespread within the project area, captured at all stations except KA 3 (sampled August only) and KA 5A (sampled November only). The highest abundances were observed at Stations KA 7, KA 10, and KA 11 (Table 4). CPUE was highest in July, but substantial numbers were also observed in August (Table 3, Figure 6). Abundance of coho dropped to less than 0.3 fish/set in September and continued to decline until November when CPUE actually increased somewhat from the October low.

Length frequency data for coho (combined over the entire sampling period) show a wide range of sizes from 41 to 120 mm with nearly half between 41 and 80 mm. Data from spring of 1983 were consistent, indicating as many as four separate cohorts may have been present (Dames & Moore 1983), but this was likely skewed by inclusion of fish released from upper Arm hatcheries. From July through September 2004, both Age 0 and Age 1 coho were present (Figure 8). There is a clear indication of net growth and declining numbers in the Age 0 cohort with a surprising apparent growth spurt between September and November (Figure 8). Without scale analysis, however, it cannot be stated with certainty that this pattern represents growth of a single cohort.

Coho Salmon – 2005. Coho salmon were the most abundant juvenile salmonid in 2005, comprising 31.1 percent of all juvenile salmon captured (Table 6). Coho were relatively well distributed throughout the Arm with CPUEs on the west side approximately 50 percent greater than those on the east (Anchorage side); mean CPUE was 1.3 fish/set on the east side and 2.0 fish/set on the west side (Table 7). Over time, CPUE increased steadily from 0.6 fish/set in April to a peak of nearly 4 fish/set in July (Table 3, Figure 6). This is consistent with 2004 data that show a peak in late July followed by a general, and significant decline through the rest of the summer and fall ($P = 0.001$, Table 8). The CPUE of coho varied significantly by the tidal stage at the time that the net was set, with more fish caught during flood and high slack tides than during ebbing and low slack tides ($P = 0.007$; Tables 8 and 9).

Length frequency data show that coho present in April were likely Age 1 outmigrants. A very small young-of-the-year cohort appeared in May with many fish less than 30 mm. Also present in May were larger cohorts, between 41 and 100 mm (>40 percent) and with progressively smaller numbers larger than 100 mm (Figure 8). Data do not show clear size trends over time although the mean sizes of young-of-the-year fish during the May through July sampling period of 2005 were clearly smaller than the coho observed during the July through November sampling period of 2004. By July, this cohort had increased in size somewhat although that growth is not evident in the 20-mm increments shown on Figure 8. As in earlier findings (Dames & Moore 1983), length data infer that several age cohorts are present in the Arm, at least during the spring. The relatively high frequency of occurrence of 101- to 140-mm coho captured in June 2005 is likely a result of the 251,000 coho released from Ship Creek hatcheries on the 13th of that month.

Chinook Salmon – 2004. Twenty-eight juvenile Chinook salmon were captured during beach seine sampling between July and November 2004, representing 17 percent of all juvenile salmonids (Table 3). Over the entire sampling season the great majority of juvenile Chinook were between 61 and 120 mm (Figure 9). Chinook were observed at all of the outer stations with the highest abundances at Stations KA 10 and KA 11 (Table 5). Over 70 percent of juvenile Chinook were captured in July, substantial decreases occurred in August (despite the greater number of stations sampled) and even greater declines were seen in subsequent months (Table 3 and Figure 6).

Based on the size distribution of Chinook in spring of 1983 and 2005, most fish taken in July of 2004 were likely Age 1 outmigrants (Figure 9). A shift in the size distribution of the Age 1 Chinook cohort was observed between July and August; this may represent growth of the cohort or the dynamic movement of different size groups through the Arm. However, the sample size was small, particularly after the July sampling event.

Chinook Salmon – 2005. Chinook salmon comprised 25.6 percent of all juvenile salmon captured between April and July 2005 and were taken at all stations (Tables 6 and 7). Mean CPUE of Chinook was virtually identical on both sides of the Arm (Table 7) and no significant difference among stations was detected (P = 0.921, Table 8). In 2005, peak abundance occurred in June at over 3 fish/set (Figure 6) while in 2004 peaks occurred in July; however, CPUEs in July of both years were significantly lower relative to May and June indicating a steady decline into mid- and late summer (Table 3).

As in 2004, the majority of Chinook were between 61and 120 mm. In April, most Chinook were small young-of-the-year between 30 and 40 mm while from May on, larger fish greater than 61 mm dominated the catch (Figure 9). Many of these larger fish appeared to be of hatchery origin as substantial releases from the Ship Creek hatcheries occurred in May.

Chum Salmon – 2004. Only five juvenile chum salmon (*O. keta*) were captured during 2004 sampling, all within the middle portions of the Arm at Station KA 7 and all during the July and August surveys (Table 3). In contrast, juvenile chum were the most abundant salmonid observed during the spring of 1983 (Dames & Moore 1983). This is consistent with the pattern of chum salmon outmigrating through estuarine areas rather quickly and remaining in the marine nearshore for relatively short periods. We conclude that most chum salmon had outmigrated from the Arm before the 2004 sampling began in late-July.

Chum Salmon – 2005. The spring sampling efforts conducted in 2005 appear to have captured the range of the juvenile chum salmon outmigration. A few chum salmon were taken in April followed by significant increases in May and June (Figure 6 and Table 3). Consistent with 2004 sampling, no chum salmon were observed in beach seine samples in July 2005. The highest abundance of chum salmon was observed within the inner Arm at stations KA 1 and KA 5, although fish were captured at all stations. Mean CPUE was essentially the same for the east and west side of the Arm (Table 7), and there was no significant difference in the 2005 catch among stations (Table 8).

All chum salmon were young-of-the-year outmigrants between 21 and 60 mm with only fish under 50 mm observed in May and a few fish over 50 mm observed in June (Figure 10), suggesting some growth over time within the Arm.

Chum salmon were fourth in abundance relative to all juvenile salmonids behind coho, Chinook, and sockeye salmon (Table 3) over the course of the sampling period. This is somewhat of a contrast with the 1983 study that found chum to be the most abundant juvenile salmonid observed during the spring. This difference in total relative abundance is likely due to the rather short duration of the 1983 study, which collected fish over a 5-week period in May and early June. During the same 5-week period in 2005, chum were among the most abundant fish in the Arm.

Pink Salmon. No juvenile pink salmon (*O. gorbuscha*) were captured in 2004 and few were expected since the larger even-year pink runs in this region of Alaska would produce odd-year outmigrants. In 2005, only 33 pink salmon were captured in 120-foot beach seines (1.9 percent of all juvenile salmonids); most of these were captured in May (Table 3). Individual fish were captured in each of April, June, and July. Fish were typical young-of-the-year outmigrants with most between 31 and 40 mm in length (Figure 11).

3.3.2.2 Adult Salmonids

Adult salmon were commonly caught in the beach seine during the July and August sampling periods (Table 3). These periods represent near peak adult migration times for pink, coho, sockeye, and chum salmon. All four species were captured during July, while adult coho salmon dominated the catch in August. In September through November, no adult salmon were captured at KABATA sites. No adult Chinook salmon were observed during the 2004 sampling period; this was expected since the adult Chinook run generally occurs in May and June, before sampling began. Similar catches were observed in 2005, with one adult Chinook salmon captured in May and several adult coho, sockeye, and chum salmon captured in July.

3.3.2.3 Threespine and Ninespine Stickleback

2004. Two of the most common species in beach seine catches during 2004 in Knik Arm were threespine and ninespine sticklebacks (*Gasterosteus aculeatus* and *Pungitius pungitius*, respectively; Table 3). Both species were commonly taken at all stations sampled with the greatest abundances among the priority stations at Stations KA 7 and KA 10 (Tables 4 and 5). Threespine were most abundant, with catch rate nearly twice that of ninespine. CPUE varied from station to station and during the different sample periods; however, both species were common throughout the summer. Numbers of both species declined in the fall and early winter except that ninespines had a resurgence, outnumbering threespines in October and November (Table 3, Figure 12).

All sticklebacks were smaller than 100 mm and there were indications that at least two age classes were present in each species (e.g., threespine stickleback in September; Figure 13). Growth through the summer is suggested by shifts in the size of the dominant cohort for both species (e.g., July through October for threespine stickleback).

2005. Similar findings were observed in 2005 with over 650, threespine stickleback captured by beach seine (Table 6). The spatial distribution of sticklebacks varied significantly (P = 0.049, Table 8), driven primarily by low CPUEs at KA 3 and KA 5 and extremely large catches at KA 7A and KA 10. Length frequency data show two distinct cohorts of threespine stickleback, especially in May through July (Figure 13), with CPUE of sticklebacks varying significantly over time (Figure 12, Tables 3 and 8). Adult fish between 50 mm and 80 mm dominated the catch in April and May, gradually replaced with small young-of-the-year between 16 and 39 mm in June and July.

Fewer ninespine stickleback were observed in 2005 possibly reflecting an early summer recruitment to the Arm. Most fish were adults between 40 and 60 mm but a significant number of smaller ninespine between 30 and 40 mm were also captured in June.

3.3.2.4 Saffron Cod

2004. In 2004, 130 saffron cod (*Eleginus gracilis*) were captured by beach seine, making this one of the most common non-salmonid species observed in the Arm during the July to November sampling period (Table 4). Cod were observed at all stations commonly sampled during the sampling period (i.e., all stations except KA 1 and KA 3, which were only sampled once during the sampling period). Catch was relatively consistent, as indicated by CPUE ranging from 0.7 to 2.5 fish per set at stations where they were observed (Table 5). The abundance of cod also increased from July through September; CPUE increased from 0.6 fish per set in July to 2.7 fish per set in September (Table 3 and Figure 14). Numbers per set declined thereafter but the percentage of cod in the total catch remained high in October and November.

Length frequency data show the likely presence of several year classes in the nearshore. Most fish observed in the summer were likely young-of-the-year juveniles between 51 and 125 mm (Figure 15). A number of fish in the 180 to 250 mm size and 251 to 375 mm size, likely representing at least three age classes of adult cod, were also observed, especially later in the year. Several of the larger adults taken in October and November were very fat (high weight: length ratio) and the single fish that was sacrificed and examined was gravid.

Clear evidence of growth in the smaller size group of cod was observed from July through September (Figure 15). No growth was apparent in this cohort between September and October but no representatives of this cohort were captured in November. In September and October, the highest frequency of occurrence was still in the 50- to 100-mm range but fish in the 151- to 250-mm range began to appear (Figure 15).

The overall size distributions of saffron cod in spring 1983 and throughout 2004 were similar. Of note, during the spring of 1983, the highest occurrence of cod came late in the sampling period in June (Dames & Moore 1983), while during 2004 summer sampling, the lowest occurrence of cod was observed in July with a steady increase into September.

2005. In 2005, saffron cod were second in abundance to threespine stickleback within the Arm and were found at most stations (Table 6). Cod abundance varied significantly by station (P = 0.016, Table 8), with large CPUEs occurring at stations KA 10, KA 13, and KA 14 and lower catches to the northeast (Tables 7 and 8).

As with 2004 data, several juvenile and adult age classes were observed during the spring and summer (Figure 15). Sampling in both 2004 and 2005 show an interesting, and significantly variable, temporal distribution of the species in the nearshore of the Arm. In April, a wide range of sizes of cod by far made up the most abundant species in the nearshore (Figure 15); high abundance and a wide range of sizes were present into May but declined sharply in June (Table 3). No cod were observed in mid-July 2005.

The increase in catch during the late summer, as found in 2004, was confirmed in Knik Arm in August 2005 (Pentec 2005). During this August sampling, cod reappeared in significant numbers at several KABATA stations and stations near the Port of Anchorage. In summary, the species appears to be quite abundant in the nearshore of the Arm early in the spring, declining to very low numbers by mid-summer, only to increase during the late summer and fall. It is not known whether the cod leave the Arm during the mid-summer months and return later in the season, or whether the fish move out of the nearshore to more offshore or demersal locations out of the reach of the beach seine. Available data suggest, but cannot confirm, that saffron cod remain in the Arm throughout the winter and perhaps spawn there.

3.3.2.5 Longfin Smelt

2004. Two-hundred-twelve longfin smelt (*Spirinchus thaleichthys*) were captured during the July to November sampling period (Table 4) making this the second most abundant species captured in 2004. Over 77 of these individuals (38 percent) were captured at Station KA 13, Point Woronzof, at the entrance to the Arm. Age groups represented in nearshore samples include transparent young-of-the-year larvae or post-larvae less than 40 mm, and sub-adult or adult fish over 100 mm in length (Figure 16). The majority of fish in September were in the 101- to 140-mm size range and may represent another age class of immature adults. Longfin smelt were relatively well distributed over the summer sampling period with CPUE ranging from about 0.5 to 1.4 fish per set though September (Figure 14, Table 3). A sharp peak in abundance in October (to over 6 fish per set) was largely the result of increased numbers of 41 to 60 mm fish but included a few larger fish up to 140 mm (Figure 16). In November, only the larger fish were taken but sampling conditions (high content of silty ice shards in the net) made finding small transparent organisms such as larval smelt in the haul very unlikely.

Few longfin smelt were observed during the spring 1983 sampling period (Dames & Moore 1983).

2005. In 2005, longfin smelt were third in abundance behind threespine stickleback and saffron cod in beach seine catches (Tables 3 and 6). As in 2004, this species was notably more abundant at Station KA 13 (Point Woronzof) near the entrance to the Arm (62 percent of all longfin captured). Substantially, but not significantly, fewer longfin smelt were captured at middle Arm stations and very few fish appeared at stations within the inner Arm. Longfin smelt began appearing within the outer Arm in May, peaking in June with a CPUE of over 6 fish/set. CPUE in July declined significantly to 3.1 fish/set (Figure 14, Table 3), but it is not known whether this represents a true decline in abundance since over 60 percent of fish observed in June were taken at the station at the southern edge of the study area near Point Woronzof (KA 13). Most longfin smelt were sub adults or adults between 81 and 140 mm with a small, but significant number of transparent young-of-the-year observed in April through June (Figure 16).

3.3.2.6 Eulachon

In 2005, 199 eulachon were captured in beach seine sets at stations within the middle and outer Arm. Several individual gravid adults were captured in April, but the bulk of fish appeared in May as post-spawn fish, indicating a relatively short spawning period within Arm streams in May (Table 3). Most fish were adults greater than 200 mm in length. Many post-spawn fish were also observed washed up on beaches at several middle Arm stations in May. Most fish (beach seine captures and washed up fish) were in poor condition, with open sores, infections, and skinny abdomens. No eulachon were observed in July through November sampling in either year.

3.3.2.7 Pacific Herring

2004. Nineteen Pacific herring (*Clupea harengus*) were captured during sampling from July through November with no distinct pattern of occurrence (Table 3). Herring were wide spread in September and October but not taken in November. Length frequency data show that all specimens were likely Age 1 between 41 and 100 mm (Figure 17). Although the number of captured fish was small, mean size of this cohort seemed to increase through the summer. Only five herring were captured during spring sampling in 1983, and these included both adults and juveniles (Dames & Moore 1983).

2005. As in 2004, relatively few Pacific herring were captured in the Arm in 2005, all in May and June (Table 3). Over half of all herring were captured at Station KA 13. Most herring were likely Age 1 between 41 and 100 mm in length with a few individual adults appearing at KA 13 in May.

3.3.2.8 Other Fish Species

Ringtail snailfish (*Liparis rutteri*) were rare through September 2004 but numbers increased and distribution was most widespread in October; numbers declined again in November (Table 3). Snailfish were also not abundant in 2005 spring and summer sampling. Twenty-four were captured, nearly 80 percent at the entrance to the Arm at station KA 13. Snailfish were observed in somewhat greater numbers during the spring 1983 sampling (Dames & Moore 1983); although only 12 were captured by beach seine and an additional 9 were taken in the otter trawl.

Bering cisco (*Coregonus laurettae*), Pacific staghorn sculpin (*Leptocottus armatus*), Dolly Varden char (*Salvelinus malma*), rainbow trout (*Oncorhynchus mykiss*) and starry flounder (*Platichthys stellata*) were observed in low numbers (five or fewer individuals) during the July to November 2004 sampling period (Table 3). Bering cisco were commonly observed during the spring 1983 sampling, likely intercepted during anadromous migrations. Notably, only five cisco were taken in the earlier spring and summer sampling period of 2005 (Table 6). Four cisco of widely divergent sizes were captured in July through September 2004, but none were taken in October or November.

3.3.2.9 Tide Stage vs. Catch

Beach seine catch was examined as a function of tidal stage for the April – July period of 2005. Of the 179 beach seine sets made in 2005, most were on higher elevation ebbing (102) and flooding tides (61) with very few on high (8) or low (8) slack tides (Table 9). High and low slack were defined as a half hour on either side of the predicted high and low tide. This distribution of sampling effort was based on the day-time tidal conditions experienced during the spring and summer, the relatively small window of defined slack tides, and the fact that very few stations were accessible at lower tidal elevations.

CPUE data show that higher catch rates were obtained during flooding tides (15.8 fish/set) relative to ebbing tides (12.9 fish/set) although the difference was not significant when all species of fish were evaluated collectively (Table 8). Of the dominant species, CPUE was higher on the flood for threespine stickleback and juvenile salmonids, except for pinks. CPUE on flooding tides was significantly higher relative to ebb for juvenile coho and sockeye salmon (Table 8) suggesting a possible preference of these species for the flood. Fewer pinks were captured on flood tides relative to ebb, but substantially fewer pinks were captured by beach seine. CPUE for threespine stickleback and chum salmon were higher on the flood, but not significantly so. CPUE for saffron cod varied significantly by tide, with more fish captured per set on the ebb tide than the flood tide (2.6 fish/set vs. 1.6 fish/set).

CPUE was significantly higher at high (22.8 fish/set) and low slack (25.1 fish/set) tides relative to the flood and ebb. However, we suspect that these catch rates may not truly represent fish abundance at slack tides because 1) numbers are highly influenced by one or two species with extreme abundances, and 2) relatively few sets were conducted at slack tides. At high slack, the CPUE of threespine stickleback was 11.3 fish/set, three times higher than on the ebb or flood. It is possible that this species may occupy nearshore waters in greater abundance at high slack, but the data are not robust. At low slack, catch rates were dominated by longfin smelt (10.4 fish/set) and juvenile Chinook salmon (7.0 fish/set). However, six of the eight low slack sets were made at station KA 13 (Point Woronzof), one of the only stations where sets could be made at lower tidal elevations. Over 60 percent of all longfin smelt collected by beach seine in 2005 were observed at KA 13, thus greatly biasing these catch rates.

3.3.3 Otter Trawl

Otter trawling was largely unsuccessful in sampling fish within Knik Arm during both the spring 1983 and summer 2004-2005 sampling periods. In July 2004, eight trawls were conducted offshore from Stations KA 7A, KA 10, KA 13, and

KA 14 (Figure 1) and only one adult starry flounder was captured along with several epibenthic crustaceans (*Crangon* and Gammaridae). Several hauls brought up large cobbles or boulders. During the August 2004 sampling event, the otter trawl was hung on the bottom and lost on the first trawl attempt. In 1983, seven trawl hauls in the Eagle Bay channel yielded only 16 fish, the majority being liparids (Dames & Moore 1983).

In July 2005, three otter trawl sets were made at locations off northern beach seining sites (KA 7A, KA 10, and KA 14). Only a single liparid was captured in the three sets, along with a few *Crangon* and Gammaridae. At a station off beach seining station KA 7A, several boulders were entrained in the net resulting in considerable damage to the bag.

3.3.4 Tow Net

3.3.4.1 General

Tow net sampling in May, June, and July 2005 provided an opportunity to begin to understand the relative distributions of fish and invertebrates in portions of Knik Arm removed from the shoreline areas. Flow meter data during tow net sampling showed a relatively consistent volume of water sampled. The median volume of water sampled was 2,435 cubic meters, with a mean of 2,568 cubic meters and a standard deviation of 163 cubic meters. The relative consistency of volume sampled during the tow net sampling validates catch per set (CPUE) comparisons of data among stations and dates.

Overall, 79 tow net sets were made, capturing approximately 2,180 fish potentially representing 14 species. Total catch and CPUE are presented in Tables 10 and 11. The unidentified larval fish in these tables may well have been larval Pacific herring since that species was abundant in zooplankton hauls taken concurrently with the tow net sampling (Pentec 2005). Most species had a significant seasonal trend in catch (Figures 18 and 19, Table 12). Total fish CPUE was greatest in the narrowest part of the Arm (Transects 2 and 3) although this pattern was driven by large numbers of threespine stickleback in those areas and variation by transect or station was not statistically significant (Transects 2 and 3, Tables 11 and 12).

3.3.4.2 Juvenile Salmonids

Juvenile salmonids were common in tow net samples across the width of the Arm. Catches were greatest at Transect 1 in the entrance to the Arm and declined to the north (Table 11) although this pattern was not statistically significant. Chum salmon was the most abundant species in May sampling

(4.0 per set) followed by pink salmon (2.5 per set). Numbers of both species dropped off significantly in June and they were largely absent by the late July sampling (Figure 18, Table 11). As in the beach seine catches, both of these species were represented by a single cohort (young-of-the-year) and each showed some apparent growth between May and June (Figure 19).

Sockeye, Chinook, and coho salmon juveniles were also common in tow net catches with catch of all three species peaking in June (Figure 18). Sockeye was the third most abundant species in overall tow net sampling (2.4 per set; Table 11), the result of high catches during June (nearly 7.0 per set). Sockeye were represented by two year classes in May with young-of-the-year showing good apparent growth through the sampling period (Figure 19). Coho and Chinook numbers were too low for meaningful length-frequency analysis; however, multiple cohorts of each species were present in May.

3.3.4.3 Other Fish

Threespine stickleback was the most abundant fish in the overall tow net catch (19.4 per set; Table 11). These numbers were strongly driven by the significantly high catches of young-of-the-year in July (Tables 11 and 12; Figure 20), primarily at Transects 2 and 3 in the central study area where over 100 fish were taken in several sets. These fish were mostly between 20 and 30 mm in length. Geographically, threespine stickleback catch was greatest at the mid-Arm transects (2 and 3) between Ship Creek and Cairn Point. Also, catch was skewed toward the north side of the Arm (Stations 3 through 5) except on Transect 2 where high catches were also made at Station 1, off the Ship Creek mouth. None of these spatial patterns were statistically significant, however.

Other non-salmonids (Pacific herring, longfin smelt, saffron cod), similar to threespine stickleback tended increase in abundance in the tow net catches later in the summer (Figure 20). Two-year classes of herring were present in May with only the smaller of these evident in June. In late July, young-of-the-year herring recruited to the catches (nearly 1.4 per set) and larger fish were absent. Herring catch was too inconsistent to identify any true trend. One large catch of herring occurred in July at Station 3-4 offshore of Port MacKenzie (Figure 3).

Longfin smelt and saffron cod numbers were too low for meaningful spatial or temporal analysis.

3.3.5 Facilities Sampling

3.3.5.1 Fixed Tow Net Sampling

Fixed tow net deployment from the Port MacKenzie trestle proved an effective means of sampling fish and invertebrates moving past the structure during periods with strong current movement (Table 13). As indicated by qualitative observations in Many and June and by the results of the July sampling effort with concurrent flow meter readings, the dominant factor in determining catch rate for fish appeared to be current velocity. However, the results of the flow meter readings were inconsistent in calculating the total volume of water sampled because the current was not uniform in its movement. As a result of the natural pattern of flow through Knik Arm, the flow meter frequently wavered in direction and speed, and the flow readings do not necessarily correspond with the actual volume sampled. According to flow meter data, the volume of water sampled with the fixed tow net ranged from 65.9 to 2,500 cubic meters. The overall median value sampled was 1,084 cubic meters, with an average of 1,155 cubic meters and a standard deviation of 792 cubic meters. Comparisons between the outermost station (PM 02) and the innermost station (PM 00), the two stations with the most sampling, indicated a similar distribution of flow, with the difference between the two medians of only 70 cubic meters. Consequently, comparisons between the stations are made with relatively high confidence.

On several occasions, the net was deployed while currents were low or moderate resulting in low to moderate catches; often the current would accelerate quickly to much higher velocities between sets, and fish catch would invariably increase as well.

Analysis of catch in fixed tow net sets as a function of tide condition (early ebb, late ebb, early flood, late flood; Figure 21) suggests that juvenile salmonids, primarily chum and coho, were significantly less susceptible to capture during late flooding tides (Table 14). Threespine stickleback were significantly absent from waters sampled during the late ebb with most fish captured on the early ebb (Table 14; Figure 21).

CPUE between the inner (PM 00) and outer (PM 02) net positions was remarkably similar when averaged over the entire study period (11.6 and 11.9 fish per set, respectively) with no significant variation detected for any taxon (Table 14). The intermediate station PM 01 had a substantially lower CPUE that likely reflects the fact that it was seldom fished when currents were strong. Because our focus was on contrasting inner and outer stations, when currents were strong near the face of the facility, we preferentially moved the gear to fish at Station PM 00.

Ten species of fish were captured in all sampling with eight or more species taken at each sample station (Table 13). Threespine stickleback dominated the total catch (42 percent) largely as a result of an abundance of young-of-the-year fish (mostly under 30 mm) taken in the last two sample periods in July.

Sockeye and coho salmon were the next most abundant species. Sockeye were represented by a wide range of sizes including at least two cohorts in June (Figure 22). The wide range of sizes present in July results either from a continuing movement of young-of-the-year from spawning areas into the Arm in early summer, a continuous outmigration of overlapping cohort sizes, and/or also the pooling of data from sampling in mid- and late July.

A very small cohort of coho was taken in the fixed tow net in June (Figure 23) with significant differences detected in CPUE between the June and July sampling periods (Table 14). These young-of-the-year, also common in the small beach seine in June (following section), may represent fry washed from gravels and streams by spring snow melt freshets. In July, the smallest of these fish were absent, either through growth, mortality, or emigration. Some indication of growth (or larger outmigrants) can be seen in the shift in size in the older cohort between June and July on Figure 23. Additionally, the large catch of 100- to 150-mm coho in June may be correlated with the release of coho from Ship Creek hatcheries.

Chinook salmon were represented by multiple age classes in June, but possibly only a single cohort was present in July (Figure 24).

There were no strong trends in in-shore versus off-shore catches but Bering cisco were only caught at stations PM 00 and PM 01 (Table 13), suggesting a shoreline orientation for this species.

3.3.5.2 Small Beach Seine Sampling

Relatively large areas of sand/mud beaches have developed through sedimentation occurring on both sides of the rock fill at the base of the Port MacKenzie pier facility (Figure 2). The small (30-foot) beach seine (Photo 3 proved to be an effective tool for sampling smaller fish utilizing the narrow zone of water along these beaches. In total, 60 sets were made with an overall CPUE of 12.8 fish per set. Fifteen species of fish including six species of salmon (*Oncorhynchus*) were captured (Tables 15 and 16). Catches were greatest at stations closest to the facility (PM N1 and PM SS and PM S1) and CPUE was remarkably similar at these stations, 16.3 to 19.0 fish per set. In general, no significant differences were detected between the north and south sides of the facility (Table 17). Because of difficult conditions (riprap on one side and soft mud on the other), only one set was made in the slough immediately south of the facility (PM SS; Photo 17). The net was stretched across the mouth of the slough and hauled toward the head of the slough by crew members on the riprap and on the mudflat. This set (June 19) yielded a high catch of young-of-the-year coho (29 to 39 mm) along with two sockeye and a longfin smelt, indicating possible preference by these small fish for an unusual area of refuge from the currents.

The tide had a significant effect on the CPUE of juvenile sockeye and chum salmonid captured with the 30-foot beach seine (P = 0.046, Table 17). Sockeye were particularly susceptible to capture on the late ebb and late flood. Sticklebacks (both species combined) also showed significant variation in catch with respect to tide (P = 0.005). Similar to salmonids, more sticklebacks were captured during the late flood but they were not very abundant during the late ebb. In contrast, the CPUE of sticklebacks was high during the early flood.

Juvenile coho and threespine stickleback tended to be more abundant on the muddier beaches north of the facility while juvenile sockeye and longfin smelt were somewhat more abundant along the firmer sandier beaches to the south.

3.4 Benthic and Epibenthic/Pelagic Invertebrates

3.4.1 General Observations

In general, the beaches of Knik Arm are devoid of obvious macroinvertebrates. Many hours of searching in the course of fish sampling as well as targeted searches for invertebrates has turned up only a very limited list of benthic infaunal or epilithic (on-rock) species. The only invertebrate seen that is not widely reported from our various sampling efforts below was the periwinkle *Littorina sitkana*; several individuals were present grazing on low intertidal rock surfaces on the south side of Point Woronzof during the spring and early summer 2005 and one was taken in a beach seine at this site.

3.4.2 Beach Seine

The 120-foot beach seine used in this study has proven remarkably effective at capturing the larger epibenthic crustaceans that represent the majority of the marine invertebrate fauna of nearshore areas in the Arm. Total CPUE by station and sampling period for the 1983, 2004, and 2005 studies is provided in Appendix B. The invertebrate assemblage captured along Knik Arm shorelines by the beach seine consisted of two species of *Crangon* shrimp, two species of gammarid amphipods, three species of shrimp from the Family Mysidae including two species of *Neomysis,* the isopod, *Saduria entomon*, and one species of polychaete worm, *Neanthes limnicola*, for a total of just nine taxa. Another isopod, *Argeia pugettensis,* is parasitic on crangonid shrimp and thus is not a true member of the invertebrate assemblage. In addition, parasitic sea lice of the copepod Family Caligidae, were often seen in the net following capture of adult salmon.

Consistent among the 1983, 2004, and 2005 sampling efforts is a trend of increasing abundance in overall invertebrate densities beginning from spring and moving into fall. In 2004 through 2005 this trend was significant (P = 0.000; Figure 25, Appendix B, Tables B-1 and B-4). Overall, CPUE was greatest during late summer/fall (August through October) 2004 in comparison to either the 1983 or spring/summer 2005 surveys. When overall CPUE data for April through July 2005 are combined with data from July through November 2004, CPUE increases steadily over the combined year, with the exception of November 2004. A sharp decline in total invertebrate catch in November was in part, the result of the large quantity of gray ice shards captured by the net in most sets. The color and size of these shards mimicked the small clear or pale gray bodied invertebrates and made their collection very ineffective. However, CPUE in November 2004 was similar to that in early spring (April 2005) when ice was not a factor. Thus, there appears to have been a real drop in invertebrate presence during the winter (November through April).

Early in the 2005 survey, the amphipod *Lagunogammarus setosus* dominated the catch, but its dominance was replaced by *Crangon franciscorum* in early May. The overall CPUE of *Crangon* species continued to increase throughout the study period, but the dominant species *C. franciscorum*, dropped off significantly in July (P = 0.000, Appendix Table B-4) and was replaced by a newly emerged cohort of *Crangon*. It is probable that this new cohort also was *C. franciscorum*, based on the progression of CPUE shown on Figure 26, but identification could not be confirmed due to small size and lack of maturity. Mysid abundance was relatively constant over the sampling period (Figure 26) until July when CPUE of mysids reached their peak in both years sampled (P = 0.000 in 2005; Appendix Table B-4). Species dominance shifted from *Neomysis mercedis* to *N. rayii* at the end of June and continued through July (Figure 26).

Over the entire 2005 survey period, the mean invertebrate CPUE at each station sampled (averaged over time) ranged from 21.5 per set (KA 5) to over 120 per set (KA 2), but combined species CPUE did not vary significantly (Appendix Tables B-2, B-3, and B-4). The sites with the greatest CPUE were dominated by crangonid shrimp and were located at the northern reach of Knik Arm (sites KA 2, KA 6, and KA 10; Figure 27, Appendix B). The only group of invertebrates that varied significantly by station was the amphipods, which were most prevalent at KA 13.

The tide at the time of sampling during the 2005 survey may also have influenced the abundance of invertebrates captured although the pattern is not clear (Figure 28). Crangonids and mysids were most affected by tide (Appendix Table B-2). In July when invertebrate CPUE was at its peak, the CPUE was highest at flooding and high slack tides. CPUE was also highest during the flood in April and May. In contrast, in June, CPUE was highest on the ebb.

3.4.3 Tow Net

A remarkable abundance of invertebrates was taken in the surface tow nets, even over the deepest part of the Arm. Invertebrate species captured in tow nets included the same largely epibenthic species captured with the beach seine, which we presumed to be capturing invertebrates from the near the seafloor in shallow, nearshore waters.

The CPUE of invertebrates in the tow net decreased significantly over time from May through July (Figure 29, Appendix Table B-5). In May, the overall CPUE of 229.7 animals per set was dominated by *C. franciscorum* (64 percent of the total catch), followed by the two species of amphipod, *L. setosus* (12 percent) and *Onisimus* sp. (16 percent), and mysid shrimp, representing just over 5 percent of the total catch. In the June sampling effort, where the overall CPUE declined to 204.5 animals per set, the dominant species shifted from *C. franciscorum* (21 percent of the total catch) to the mysid *Neomysis rayii* (31 percent). Both species of amphipod increased in abundance in the month of June as well. During the month of July, catch was dominated by a cohort of small *Crangon* shrimp (31 percent of total catch) that was not identified to species because of its size; likely these animals represented a young cohort of *C. franciscorum*. The July catch also showed an increase in both species of amphipods and a decline in mysid shrimp. Continued sampling of Transects 2 and 3 in August and September 2005 (Pentec 2005) yielded higher catches of invertebrates, matching the increase numbers in the 120-foot beach seine in late 2004 (Figure 25).

Invertebrates were distributed relatively evenly by tow net transect and station, with no significant variation detected (Appendix Table B-5). Transect 5 (south side of Eagle Bay) had a CPUE higher than the mean, and Transect 6 (north side of Eagle Bay) had a CPUE that was substantially lower than the mean (Figure 30). The high CPUE at Transect 5 was driven primarily by a large catch at Station 5-2 that was dominated by *C. franciscorum* and (surprisingly) the benthic isopod *S. entomon* in May. Distribution of overall invertebrate catch appeared to be relatively even across each transect (i.e., with respect to distance from shore), with the exception to Station 5-2, mentioned previously.

3.4.4 Facilities Sampling

3.4.4.1 Fixed Tow Net Sampling

Fixed tow net sampling (Photo 2) proved an effective method for measuring the relative abundance of invertebrate species in waters moving around the Port MacKenzie facility. As was seen in the results of the fish sampling using the same method (Section 3.3.5.1), the fixed tow net was most effective at capturing invertebrates when placed at a late ebb or early flood tide (Figure 31) and catch was definitely greater during periods of high flow velocity. During the late flood, very few invertebrates were collected just as very few salmonids were collected during the same tidal condition. However, CPUE did not vary significantly with tide (Appendix B, Table B-6).

Invertebrate CPUE was much higher in June than in July (Figure 32). The decline in abundance in the July sampling effort is most apparently driven by declines in all mysid shrimp (Appendix Table B-6). *Crangon* spp. showed similar trends in the fixed tow net sampling as in the surface tow net sampling in that *C. franciscorum,* abundant in June, was replaced by a smaller cohort of *Crangon*, possibly also *C. franciscorum* in July. More invertebrates were captured per set from the inner (nearshore) Station PM 00 than the outer Station PM 02 (Table 19) with significant differences detected in the number of mysid shrimp between the two stations (Appendix B, Table B-6).

3.4.4.2 Small Beach Seine Sampling

More invertebrates were captured in the small beach seines fished along the mudflats north and south of Port MacKenzie on late ebb and late flood tides than during early ebb and early flood tides (Figure 33). Slightly more invertebrates were sampled on the south side of the facility than the north side of the facility, particularly at the southernmost site (Table 20; Figure 34). Invertebrates were most abundant at the south slough site (PM SS) with the riprap on one side and soft mud on the other (Photo 17), where only one set was made due to the difficult conditions. The high CPUE at PM SS was driven primarily by the small, unidentified *Crangon* species and may be attributed to the fact that only one set was made at the station.

3.4.5 Benthic Cores

Even with highly biased sampling that targeted areas of finer sediments and areas with obvious evidence of presence of polychaetes, the numbers of invertebrates taken in the cores were extremely low. Only two infaunal species were identified from the 50+ cores processed in 2004 and 2005.

The most abundant, reflecting the focused sampling approach, was a nereid polychaete identified as *Neanthes limnicola*. It is uncertain whether this polychaete is the same as the new species reported by Kudenov (2002) along Turnagain Arm. He reported that the species was found in mudflats seaward of marshes that parallel the coast between Point Woronzoff and Potter Marsh. A scientific description and proposed name for this species are not available.

The species found in Knik Arm was also abundant in high elevation mudflats seaward of marshes where densities approaching 500/m^2 were documented in core sampling focused in areas with high worm tube density visible at the mud surface. This polychaete was also found in a variety of other habitats, including the undersides of cobbles embedded in clay over a wide range of tidal elevations, and in small tide pools on low tide sand and clay benches were also found. Activity by this species on or above the sediment surface is indicated by its visible tracks (Photo 18) and its frequent occurrence in beach seine catches, especially in October and November 2004.

The only other true infaunal species present was the small bivalve, *M. balthica*, observed only at Stations KA 11 (in a beach seine set) and KA 16.

4.0 DISCUSSION AND CONCLUSIONS

4.1 Gear Efficiencies

Four different gear types were used to capture fish and invertebrates in various habitats in Knik Arm. In each case, data are primarily reported as CPUE for the purpose of examining the temporal and spatial patterns of fish distribution in the Arm. Each gear type was initially set up to fish in a standard way. It should be kept in mind, however, that all sets with a given gear type are not equal, especially in a challenging environment such as Knik Arm. For example, the large beach seine could be very difficult to retrieve in the strong currents common in the Arm. When encountered at a given station, these currents were accommodated in one of two ways. One way was to fish at a somewhat different location (e.g., in an eddy north of a point during a strong flood tide) or moving laterally along the beach with the current as the net was hauled into the beach. These modifications made sampling possible at each station under most current conditions. However, non-standardized fishing techniques may have generated variability in the total volume of water fished by the net that may bias comparisons among CPUE values in uncertain ways.

Likewise the tow net was fished for a nominal 5-minute period both offshore and when fixed to the Port MacKenzie trestle. Ideally, one should use a concurrent flow meter reading to standardize the volume of water fished (e.g. Moutlton 1997). In this study, flow meter readings were not obtained until the July sampling event. In the offshore sampling, lack of flow data is probably not greatly important for standardizing the volume of water fished because the two boats pulled the net at standard RPMs while moving against the current. Because of the influence of strong and eddying currents on the boats and net, the path traveled during each set was highly variable. It was nearly impossible to maintain a straight line while heading into the current, and the net was often towed in an arc or even a nearly full circle. Currents also greatly influenced the exact point to which the sample should be attributed. There was a substantial variation in the center point of all tows at each of the sample points shown on Figure 3.

For the Port MacKenzie tow net application, the net was fixed and relied on highly variable currents to fish. There, a strong influence of current velocity on catch was observed, with larger CPUE values strongly correlated with stronger flows.

These sources of variability in the physical attributes of each "set" are partially offset in many cases by the large number of sets with each gear at each station, yielding average catches that likely approach a true average for the location.

The reliability of the sample gears employed for sampling invertebrates was certainly a function of the same factors described above for fish. In addition, smaller invertebrates were quite capable of passing through the mesh of the nets, especially the wings. Active amphipods would often crawl through the mesh. Smaller mysids and *Crangon* could be passively swept through the mesh. Nonetheless, the data described in Section 3.4 do provide a picture of the nature and relative abundance of invertebrate assemblages in the Arm.

4.2 Comparisons with Other Studies

4.2.1 Fish

These studies were initially designed to build on and complement beach seine sampling conducted in 1983 by Pentec staff (Dames & Moore 1983) in support of the earlier Knik Arm Crossing proposal. In the 1983 work, beach seining was the primary tool used to document the nature of fish and invertebrate assemblages between Point Woronzof and Fire Creek on the south/east side of the Arm, and from Point MacKenzie to Fish Creek on the north/west side of the Arm. That study was focused on the spring outmigration of juvenile salmonids and extended only from the first of May through the first week in June. A more recent study by Moulton (1997) employed a surface tow net to sample fish in open water areas southwest of Knik Arm, from Fire Island south to the Forelands. This study, conducted from June to early September 1993, showed a high degree of usage of central inlet waters by a variety of species, including juvenile salmonids.

The present study began with beach seining in late July 2004. We attempted to sample as late as possible into the winter and to begin as early as possible in spring of 2005. Our November sampling encountered considerable logistic difficulty due to ice conditions that are detailed in the field summary in Appendix A. Only a limited number of stations could be sampled because of beach ice accumulations and/or dense ice moving along the shorelines. Seine hauls were hampered by hanging up on submerged (and therefore invisible) bottom fast beach ice and once on the beach, sorting smaller species, especially invertebrates from ice in the bag was very inefficient and no doubt missed many animals. Despite these difficulties, November sampling did detect a surprising level of biological activity including the continued presence of juvenile coho and of larger and gravid saffron cod. This latter species is reported to move into estuaries and tidal portions of rivers to spawn in late fall to early winter (Svetovidov 1948, Mecklenburg et al. 2002).

The present study demonstrated some interesting consistencies with the 1983 Knik Arm work, despite the disparity in sample periods and stations. Species lists are relatively consistent although one of the more rare species captured in 1983, yellowfin sole (*Limanda aspera*) was not taken in the recent sampling (Appendix C). Three others including walleye pollock (*Theragra chalcogramma*); Pacific tomcod (*Microgadus proximus*); and snake prickleback (*Lumpenus sagitta*) were rare in 2004/2005 but not taken in 1983. The abundance of eulachon was very similar in the springs of 1983 and 2005 (2.0 per set in 1983; 2.65 per set in May 2005). In contrast, Bering cisco were considerably less abundant in 2004/2005 than in 1983.

By far, the most abundant fish observed in the Knik Arm nearshore was the small forage species threespine stickleback. This species comprised 45 percent of all fish collected in 2004 and 25 percent of fish collected by the large beach seine in 2005. The two sampling periods documented a pronounced seasonal presence of both juvenile and adult life stages in the Arm. Threespine stickleback was also the most abundant fish species in tow net catches by Moulton (1997) between Fire Island and the Forelands and comprised over 90 percent of fish in our tow net catches on Transects 2 and 3 in Knik Arm in August and September 2005 (Pentec 2005).

Juvenile salmon were also dominant species within the Arm, collectively second in abundance to threespine stickleback in 2004 and most abundant in large beach seines in 2005. In summer/fall 2004, sockeye were the most abundant salmonid, followed by coho, Chinook, and chum; and in spring/early summer 2005, coho were most abundant, followed by Chinook, sockeye, chum, and pink. In 2005, however, although timing of peak abundance varied, the total abundances of the five juvenile salmon species were similar, except that pink salmon were relatively less common in beach seine catches.

Together the two sampling periods (2004 and 2005) covered the entire juvenile salmon outmigratory period, as shown on Figure 6. Juvenile pink and chum salmon had the shortest residence in the Arm showing in small numbers in April, peaking in May and June, before declining sharply. No chum salmon were observed in beach seine sets from July through November. Relatively few pink salmon were observed in April. Numbers peaked in May and declined sharply with a few remaining in June and July. Chinook were also found in low numbers in April, increasing to a peak in June and declining in August. A few individuals were found in the Arm in September and October 2004. Data from 2004 and 2005 show that, of the salmonids, coho and sockeye had the largest and longest presence in the Arm. Coho were the most abundant juvenile salmonid in April, increasing to a peak in July before declining, but maintaining a presence in the nearshore Arm through November. Few sockeye were observed before May but they were highly abundant from June through August, before declining in September and October.

Data from 2004 and 2005 show that saffron cod had a significant presence in the Arm over much of spring, summer, fall, and early winter. Saffron cod was the only species aside from threespine stickleback that maintained a combined CPUE greater than 1 for five of the eight months sampled in the Arm.

Two smelt species were seasonally highly abundant within the Arm—eulachon during the spring and longfin smelt during the summer and fall. The anadromous eulachon was present during a relatively short period during its spawning run in May. Longfin smelt had a varying but extended presence from June through October, sometimes in dominating numbers in individual sets.

In seasons not sampled in 1983 (July through November and April), we noted some interesting changes in fish presence in the Arm. For example, we found an abundance of longfin smelt and relatively few cisco in mid-summer to fall 2004 and summer 2005. Similarly, Moulton (1997) did not take any Bering cisco in his surface tow net sampling in summer of 1993. Threespine stickleback were much more abundant in Knik Arm in spring 1983 (40.6 per set) than in the spring 2005 sampling (2.9 per set in April through May 2005). This disparity likely reflects the additional sampling at stations closer to the mouth of the Eagle River and Fish Creek in the 1983 work. A large influx of young-of-the-year threespine stickleback occurred in July 2005, both in nearshore beach seines (as might be expected) and in offshore tow net and fixed tow net sampling. The presence of large numbers of these very small fish (some less than 20 mm) in offshore waters, and general lack of variation between nearshore and offshore waters, was surprising and suggests that they are subject to being swept from shoreline areas by the high currents extant in the Arm.

When CPUE for threespine sticklebacks is removed, the CPUE for all other species in 120-meter beach seines was virtually identical between 1983 and 2004 (7.4 fish per set and 7.9 fish per set, respectively) but increased to 11.2 in 2005. This similarity would be somewhat closer if adult salmon numbers were eliminated. Only a few adult Chinook salmon were captured in spring sampling in 1983 (and 2005), while a substantial number of adult coho, sockeye, and pink salmon were captured in the July and August sampling in 2004 and in June and July sampling in 2005.

Using a surface tow net and hydroacoustic methods to document use of nearshore and mid-channel pelagic habitats, Moulton (1997), captured substantial numbers of juvenile salmonids, predominantly pink and chum salmon, with lesser numbers of Chinook, sockeye, and coho. As in the present study (both in tow net and beach seine), and in the 1983 Dames & Moore study, threespine stickleback was the most abundant species. However, Moulton (1997) also identified Pacific herring and eulachon among the top four species in abundance, along with pink salmon.

From May through July 2005, we added tow net sampling to investigate fish use of mid-channel areas of Knik Arm for comparison with Moulton's findings and to provide information regarding the relative use by various species of shoreline versus mid-channel areas. The most abundant juvenile salmonids in our tow net catches in May and June, as in Moulton's, were pinks and chums. Catches in the two studies are consistent with the general migratory behavior of juvenile salmon. While our catches in Knik Arm declined substantially between May and June (Figure 17), catches just outside of the Arm south of Fire Island were steady (pinks) or increasing (chum) from June to July. Catch per set (Moulton's data corrected to 5-minute trawls) was much greater for pink salmon south of Fire Island in June and July (0.3 to 9.6 per set) than in our May and June sampling in the Arm (2.5 and 0.6 per set, respectively). On the other hand, chum were more abundant in our catches north of the island in May (4.0 per set) than they were south of the island through June. In July, however, most pinks and chums were gone from the Arm, yet increasing in catches south of Fire Island. This is consistent with expected movement of the species out of Cook Inlet corresponding with their seaward migration. Catches of juvenile Chinook, coho, and sockeye peaked during June in our tow net catches (Figure 17). Juvenile salmonid catches in Moulton's (1997) study peaked slightly later, with Chinook peaking in mid-July, while sockeye and coho catch rate varied in a narrow range through from early June to mid-July. Coho was the only species of juvenile salmonids present in Moulton's catches in early September. This is consistent with our finding from fall of 2004 that coho were the most abundant salmonid present late in the year.

The fact that juvenile pink and chum salmon were relatively more abundant in Knik Arm tow net sampling than in beach seining suggests that these two species are not particularly associated with shorelines in the Arm. In contrast, Chinook and coho CPUE was much higher in the 120-foot beach seine than in the tow net while juvenile sockeye were approximately equally abundant in each environment (gear type).

Examination of catches in the tow net when fished offshore in June and July with catches for the same net fished from the Port MacKenzie trestle yielded some interesting comparisons (Note however, the qualifiers discussed in Section 4.1). Overall, the catch rates for the two sample methods were fairly similar in June (8.3 fish per set at Port MacKenzie and 11.2 fish per set in the offshore tow nets). In July the catch in both methods went up sharply due to the influx of high numbers of young-of-the-year threespine stickleback (17.9 per set at Port MacKenzie and 81.7 per set offshore). If threespine stickleback are removed from the July numbers, catch rates are much more comparable: 6.3 per set at Port MacKenzie and 5.3 per set offshore.

In comparisons of total CPUE in the two tow net programs, chum salmon were more abundant in the offshore sampling, while coho were more abundant nearshore, consistent with the comparisons between beach seine and offshore tow net described above. Sockeye and Chinook were equally abundant in both tow net programs. This (and the high catch of pink salmon in the offshore tow nets in May when no sampling occurred at Port MacKenzie) suggests that smaller fish (including perhaps young-of-the-year sockeye and threespine stickleback) are more likely to be entrained in the strong central Arm currents and be carried more or less passively out of the Arm with the net southerly water flow. Larger juvenile salmonids such as coho (and perhaps Chinook) may selectively be able to orient and remain along the shoreline areas, although the data are not conclusive.

4.2.2 Invertebrates

A considerably greater effort was made in the present study to collect and count all invertebrates captured by the nets than was made in the Dames & Moore (1983) field work (J. Houghton, personal observation). Possibly as a result, the nine taxa of invertebrates taken in the beach seine and tow net sampling included two species not taken in the Dames & Moore (1983) beach seining at many of the same stations. Of these, the amphipod *Onisimus* sp. was fairly common in our spring beach seine samples and may have been missed by the earlier field crews or taxonomists. The second, the polychaete *Neathes limnicola* was not captured in our spring 2005 beach seining so its absence in the spring 1983 samples is not surprising.

The amphipod *Onisimus* sp. represents an interesting animal that was one of the most important species of invertebrates in the surface tow net samples and was occasionally seen in the clean surface water layers in the Arm. This species may thus represent an important prey for surface feeding fish and birds. Indeed, Dames & Moore (1983) reported that amphipods were important prey for both juvenile salmonids and saffron cod in the Arm. Mysids were also highly important prey for saffron cod and Bering cisco, comprising more than 70 percent of prey numbers identified in stomachs. Likewise, the marine polychaete (*Neanthes limnicola*) has been found to contribute to nearly 20 percent of the biomass in the diets of juvenile Chinook (Pentec 2005). Despite their ubiquity in the Arm, *Crangon* spp. were surprisingly poorly represented in fish stomachs during the spring of 1983 and our data showed a seasonal decline in abundance of *Crangon* over the summer and fall.

4.3 Apparent Growth and Movements

4.3.1 Apparent Growth

Juxtaposition of the spring 2005 length-frequency histograms with those from July through November 2004 (Figures 7 through 9) allows some reasonable hypotheses to be made about growth of juvenile salmonids and other species during the year. Numbers of fish captured in November were so low that extrapolations of growth into that period must be viewed with caution. Also, apparent growth, or lack thereof can result from increasingly larger fish moving into the area, or to a continuing flux of same-sized fish moving through the area, respectively.

Coho salmon. Both the 1983 and 2005 spring beach seine sampling (Dames & Moore 1983 and Figure 8) showed multiple year classes of coho salmon to be present. Young-of-the-year (mostly fish under 45 mm) recruited strongly to beach seine (and tow net) sampling in May with still smaller fish (30 to 40 mm) showing up in the small seine sampling at Port MacKenzie in June. An apparent growth pattern can be traced from the 40 mm node (May to July 2005) to the 70 to 80 mm node in October 2004. In comparing the July 2004 and 2005 data

(Figure 8), the larger size of the Age 0 coho in July 2004 may be the result of the later sampling in 2004 (end of the month cf mid-month in July 2005).

Chinook. Like coho, Chinook salmon were represented by several year classes in the springs of 1983 and 2005. Small numbers of very small (less than 50 mm) young-of-the-year migrants were present in April 2005, but seemed to be absent in May 2005. Poor survival from this life history strategy has been reported in Puget Sound estuaries (Beamer and Larsen 2004) that likely have much more favorable conditions for growth and survival than does Knik Arm (see Section 4.4). In May 2005, all Chinook taken in the large beach seine appeared to be Age 1 or 2 outmigrants, although two Age 0 were taken in the small beach seine at Port MacKenzie in June and in the large seine in July 2004. A cohort of Chinook centered around 70 mm in July 2004, appeared to have grown considerably by August 2004 (Figure 9).

Sockeye. Like coho and Chinook, sockeye salmon seem to exhibit a number of different life history strategies in their use of and passage through Knik Arm. No sockeye were taken in April 2005 beach seine samples. The small number of sockeye taken in May 2005 (and in May/June 1983; Dames & Moore 1983) ranged widely in size (Figure 7), likely representing fry, Age 1, and Age 2 outmigrations from their natal streams. The Age 0 cohort from May 2005, displayed some apparent growth in June (or larger fish had entered the Arm) but little change by July 2005. These fish (size peak at 60 mm in June and July 2005) were considerably larger than the smallest cohort present in summer 2004, which did not reach this size distribution until September (Figure 7).

A similar apparent growth pattern was observed in both offshore tow net samples and with the fixed position net off the Port MacKenzie pier. Again, few sockeye were captured in May with a wide size range likely representing two or more age groups. Apparent growth was evident with Age 0 outmigrants, which increased in size over the June and July time period (Figure 19).

Chum and Pink. Residency of pink and chum salmon juveniles in the Arm is brief, but a steady increase in the maximum size of chum was apparent from April through June 2005, both inshore in the beach seine samples and in offshore tow net samples (Figures 10 and 19). This steady growth during their brief residency was also observed by Moultan (1997) in offshore tow net samples.

Very few pinks were observed in the nearshore, but a substantial number were found in offshore tow net samples and apparent growth was seen from May to June (Figure 19).

Threespine Stickleback. In early spring (April) 2005, only older, in some cases mature threespine stickleback were present (Figure 13). Beginning in May, a very few smaller fish (30 to 40 mm) were present. In June and July, a large influx of even smaller fish began to show in all sampling gears. These fish (15 to 30 mm) were particularly abundant in offshore tow nets in July (Figure 20). A similar cohort was present in the large beach seine in July 2004. The size of these fish showed little change in August 2004. The smallest cohort was much larger in September 2004 but this apparent growth is too great to be real. More likely, the smallest of this group either died out, migrated back into stream mouths, or was carried by currents to the south where threespine stickleback comprised 25 percent of all fish taken in tow nets by Moulton (1997).

Saffron Cod. A wide range of sizes suggesting at least three-year classes of saffron cod was present in the Arm in the spring of both1983 (Dames & Moore 1983) and 2005 (Figure 15). The size of the smallest year class present in May/June 1983 (peak at 120 to 150 mm) was somewhat smaller than the same group of fish in April 2005 (125 to 175 mm) and May (150 to 200 mm). This group of fish was largely absent from the Arm after May 2005. A new cohort in the 50 to 100 mm range was present in late July 2004 and showed good apparent growth into September 2004, but little change in October (Figure 15).

4.3.2 Apparent Movement

As noted above, a group of fish of a given size range with no apparent growth may represent a group that is continually recruiting at a given size and moving out of the study area rapidly. An example of the movement of different age classes of juvenile salmonids through the system can be seen in the older age classes of sockeye, Chinook, and coho that were present in the spring (both 1983 and 2005) but largely gone in July of both 2004 and 2005. The rapid movement of chum and pink fry through the system has been previously noted, as has the apparent movement in and out of the Arm of species such as saffron cod.

A major movement evident in the data is the general movement of fish of most species out of the Arm as winter approaches. CPUE by month from April through July 2005 ranged from 8.2 fish (all species) in April to a high of nearly 20 in June. July values in both 2004 and 2005 were approximately 16 fish per set and stayed relatively high through October 2004. CPUE dropped sharply (to 2.5 per set) in November. While some of this decline was likely due to reduced net effectiveness under conditions of moving and shore-fast ice, the majority is attributed to a general absence of fish.

4.4 Knik Arm Ecological Conditions

A major concern surrounding proposals to build structures along the shorelines of Knik Arm is the effect of such structures on shoreline habitat and habitat functions, especially for the rearing and migration of juvenile salmonids. A summary of ecological conditions in the Arm and resulting influence on the ecology and behavior of important resources is essential to addressing that concern.

4.4.1 Relevant Physical Conditions

Knik Arm has the following physical conditions that shape the environment of the Arm and the nature and quality of habitat provided for animals living within the Arm for all or a part of their life history:

- Deep channels flanked by shallow intertidal and shallow subtidal benches that may be sand, mud (hard or soft), or gravel/cobble, depending on location.
- Intertidal and shallow subtidal (littoral) substrates that generally get more coarse to the south and finer to the north (Section 3.2).
- Extreme tides (mean tide range of 25.9 feet; extreme range of about 38 feet).
- Extreme tidally generated currents (routinely exceeding 5 knots; occasionally exceeding 7 knots locally; Britch 1976).
- Winter water temperatures near freezing (Section 3.1).
- Low and variable salinities ranging from about 1 part per thousand (ppt) in the upper Arm in the summer to 20+ ppt in the lower Arm in the winter (Section 3.1).
- High suspended sediment load with turbidities in the hundreds of NTU or more and Secchi depths of only a few centimeters (Section 3.1); sediment sources include glacial rivers and eroding bluffs.

- High rates of sediment delivery to the shorelines from the near continuous eroding bluffs from Point MacKenzie and Cairn Point north, resulting in geologically unstable areas of fresh sediment that is continually moved by wave, current, and ice action (Pentec field notes).

- Seasonal ice formation on the mid to upper beach; gouging of intertidal and shallow subtidal by moving ice.

4.4.2 Resulting Trophic Conditions

The physical conditions listed above create unique habitat conditions and have a strong influence on the nature of the ecological habitats and processes that can occur in Knik Arm. Many of the generalizations common to littoral habitat functions in other parts of Southcentral Alaska are partially or totally inapplicable in Knik Arm. The following general trophic conditions have been documented or can be hypothesized:

- Low benthic primary productivity; small patches of macroalgae (rockweed and annual green algae are present on occasional boulders and riprap as far north as Cairn Point and the Knik Dock; Section 3.2). Microalgal activity is low except in tidal marshes and high mudflats where some carpets of blue green algal growth develop over the summer. Low densities of saltmarsh plants (especially *Puccinellia* and *Elymus*) were occasionally seen on upper beaches in mid- to late summer but these plants did not survive the winter icing.

- Minimal, if any, pelagic primary productivity (high suspended sediment load likely reduces the compensation depth to a few centimeters).

- Significant contributions of organic carbon from high salt and/or brackish marshes, especially in the major stream estuaries (Goose Bay, Eagle Bay) and high marsh benches in embayments (Ship Creek to Point Woronzof).

- Significant contributions of organic carbon from streams, especially during spring breakup (seen in beach seine and tow net hauls).

- Low to moderate density and diversity of invertebrates (Section 3.4) available as potential prey for higher consumers such as fish and birds.

- Majority of invertebrates are generally larger in size than can be consumed by comparably small juvenile salmon (i.e., young of the year of all species).

- An apparent near absence of invertebrates during the winter (November through April; Figure 25).

- Abundance of smaller primary consumers such as copepods expected to be low, as reported by (Pentec 2005).

These trophic conditions have strong implications for the life history and survivability of all species that live in the Arm.

4.4.3 Effects on Salmonids and Other Species

The extreme turbidity and poor visibility in the Arm must severely limit the success of visual feeding by fish in all but a small portion of the total habitat present. Surveys by Dames & Moore (1983) included stomach content analyses of the majority of the fish species found in the Arm. They found an unexpected level of feeding on invertebrate species found in the Arm, indicating that some level of visual feeding is possible in the Arm. Based on our recent (2004 – 2005) observations, visual feeding may be possible in microhabitats within the surficial water in the Arm where short periods (minutes) of relative quiescence in the generally turbulent water allow partial clearing (Section 3.1). In these areas where turbidity can fall to 40 or 50 NTU, visual feeding by fish or birds is certainly possible (e.g., Bisson and Bilby 1982) and we occasionally saw amphipods foraging on organic materials in the surface lens. Also, on August 25, 2004, we observed a flock of phalarope feeding along a tide rip with an accumulation of organic debris (needles, leaves, and bark). A sweep through the area with a fine mesh dip net captured an abundance of amphipods (*Onisimus* sp.). We have also observed surface feeding by saffron cod where they appeared to be feeding on crustaceans in the clearer surface microhabitats.

We hypothesize that juvenile salmonids also can feed in these small lenses of clearer waters where prey can be seen. From our observations, it appears that these areas can occur along shorelines as well as in the middle of the Arm. Our tow net sampling has shown substantial presence of juvenile salmonids in the open waters of Knik Arm. Our data and those of Moulton (1997) in offshore surface waters of upper Cook Inlet south of Fire Island, suggest that these fish, at least, were not favoring shorelines. Many of the fish, including many small individuals (e.g., chum and sockeye less than 50 mm in length) appeared to have very full stomachs. Stomachs of these juvenile salmonids were generally full of aphids, but polychaetes and amphipods also contributed to the overall biomass of salmonid diets (Pentec 2005). These data are consistent with Dames & Moore (1983), who also found a high dependence by juvenile salmonids captured in the Arm on terrestrial insects (nearly 75 percent of prey items) with amphipods, aquatic insects, and mysids also important.

Other relevant effects of the high turbidity in Knik Arm on fish living there are as follows:

- Extreme orientation of adult salmon to shallow nearshore areas; adults were often seen in less than 2 feet of water where they may gain some refuge from beluga whale predation.

- Lack of schooling by juvenile salmonids and by other normally schooling fish such as herring and smelt (distribution of catches and general observations do not suggest schooling occurs in the Arm); visual cues necessary for schooling are generally lacking and there is little need for the protection provided by schooling, since there are few visual predators on them (i.e., few if any avian predators or piscivorous fish).

- Lack of smaller epibenthic and pelagic zooplankton (e.g., harpacticoid and calanoid copepods; Pentec 2005) that are often reported as important prey for juvenile salmonids in estuaries (Simenstad et al. 1982).

Analysis of the data from 1983 and 2004-2005 shows a picture of prolonged use of the Arm by juvenile salmonids. Some reasonable hypotheses can be made (Sections 3.3 and 4.3) about growth of juvenile salmonids and other species through the open water period. Numbers of fish captured in November were so low that extrapolations of growth into that period must be viewed with caution.

Also evident are some suggestions of the movement of different age classes of juvenile salmonids through the system. Prime examples are the older age classes of sockeye, Chinook, and coho that were present in the spring of 1983; some of these cohorts were discernable in July 2004, while others were not present.

Visual examination of data from 1983 suggested that there is no significant trend of use of the east side vs. west side of the Arm for juvenile salmonids as a group. CPUE of chum salmon in the large beach seine was somewhat higher on the east side while CPUE of coho and sockeye was greater on the west side. Statistical analysis of 2005 large beach seine data for effects of station, showed no significant difference in catches of juvenile salmonids (combined), adult salmon, longfin smelt, or all species combined (Table 8). No other geospatial trends are evident in the data except that juvenile sockeye salmon were more abundant at upper Arm stations than at lower Arm stations. The trend for greater catches during flooding and high slack tides (cf ebbing and low slack tides), seen in 1983, was also evident in 2005 and was statistically significant for coho, sockeye, and saffron cod (Table 8).

4.4.4 Importance of Littoral Habitat

The traditional functions of littoral habitats for nurturing of juvenile salmonids are often described as follows. These are areas that provide:

- Shallow water refuge from predators (e.g., Heiser and Finn 1970).
- Structures such as large woody debris, eelgrass and kelp beds that provide refuge from predators (e.g., Brennan and Culverwell 2001).
- Abundant prey, including epibenthic zooplankters such as harpacticoid copepods, amphipods, and mysids (e.g., Simenstad et al. 1982).
- Reduced salinity in stream mouths and smaller estuaries that provide relief from the osmoregulatory stresses of saltwater adaptation (e.g., Myers et al. 1998).

Most of these functions are not provided by Knik Arm shorelines. For example, shallow water and structure are not necessary as refuge for juvenile salmonids because there are few, if any, predators and because predation by piscivorous birds and fish that may be present, is typically visual. Juvenile salmonids have been shown to use plumes of turbid water as refuge from predation (Cyrus and Blaber 1987a and 1987b); Knik Arm has an abundance of turbid water. While we have captured large numbers of amphipods, mysids, and crangonid shrimp at times in our beach seining, tow net data indicate that these prey types are also abundant in offshore waters, as are juvenile salmonids. In fact, two species widely reported as shoreline dependent in their early marine life history, pinks and chum, were relatively more abundant in offshore tow net catches than in beach seine catches (Table 3 cf Table 10).

The primary food base for crustaceans in the Arm is likely organic matter from the streams and marshes; that material is not selectively present on the shorelines; therefore, it appears that the crustaceans themselves are not as closely associated with beaches and shallow subtidal areas as are crustaceans such as cumaceans, harpacticoids, and corophiids that are important components of juvenile salmonid diets in other areas. Tow net catches in waters in excess of 100 feet deep in the Arm had substantial numbers of invertebrates and fish typically considered to be bottom-associated (e.g., *Saduria* and *Liparis*).

Thus, at the very least, juvenile salmonids in Knik Arm are not dependent on littoral habitats for the same reasons as they are in clear water areas of Southcentral Alaska. Also, it seems quite likely that juvenile salmonids in Knik Arm are not as dependent on littoral habitats as are the same species elsewhere.

Tow net catches (both in open water and at the Port MacKenzie facility) suggest that smaller salmonids and threespine stickleback, at least, are swept back and forth through the Arm entrained in strong tidal currents and only a small portion of these fish are along the shorelines at any given time. Yet these fish, like those captured in beach seines along the shoreline, seem able to feed successfully on the available prey.

4.5 Beluga Prey Implications

A primary objective of this work was to understand patterns of fish abundance in Knik Arm, in coordination with on-going studies of beluga whales, so that inferences can be drawn about beluga prey dependencies. However, because of delays in gaining approval for beach seine sampling in areas known to be frequent by belugas (finally gained in mid-November 2004 and again in June 2005), our sampling results cannot be as closely tied to beluga prey availability as they might have been. In August 2004, we sampled the northern stations (KA 7, KA 3, and KA 1) within a few hours after a large group of belugas had been observed in the area. Similar sampling was conducted in May 2005 at stations KA 3, KA 1, and KA 2 after belugas had moved north with the flooding tide. On two occasions, we had completed sampling a stations (KA 14 and PS 02; see Pentec 2005), with relatively poor catches when belugas moving into and through the area. Saffron cod was the only species present greater than 200 mm in length in either case.

Based on extrapolations from the data from the 1983 and 2004-2005 sampling, the species available and most likely comprising the majority of beluga diets are as follows:

April	Hooligan (eulachon), saffron cod
May	Hooligan, Chinook salmon, saffron cod
June	Chinook salmon, saffron cod (questionable)
July	Pink, chum, sockeye, and coho salmon
August	Coho salmon, saffron cod
September	Saffron cod, longfin smelt
October	Saffron cod, longfin smelt
November	Saffron cod

Additional study of fish populations with sampling more closely targeting areas of beluga feeding is needed to confirm beluga diet in Knik Arm.

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TABLES

Table 1 - Knik Arm 2004 and 2005 Sampling Effort by Station and Gear Type

		Sample Type					
Month Year	**Parameter**	**120-ft Beach Seine**	**Invertebrate Cores**	**Tow Net**	**30-ft Beach Seine**	**Fixed Tow Net**	**Otter Trawl**
Jul 04	Stations	7	6	0	0	0	4
	Sets	19	36	0	0	0	8
Aug 04	Stations	9	0	0	0	0	1
	Sets	17	0	0	0	0	**
Sep 04	Stations	8	0	0	0	0	0
	Sets	25	0	0	0	0	0
Oct 04	Stations	7	0	0	0	0	0
	Sets	20	0	0	0	0	0
Nov 04	Stations	7	0	0	0	0	0
	Sets	10	0	0	0	0	0
Total No. of Sets - 2004		**91**	**36**	**0**	**0**	**0**	**8**
Apr 05	Stations	10	0	0	0	0	0
	Sets	47	0	0	0	0	0
May 05	Stations	10	0	22	0	0	0
	Sets	74	0	34	0	0	0
Jun 05	Stations	10	0	24	6	3	0
	Sets	29	0	25	32	38	0
Jul 05	Stations	10	6	20	7	3	3
	Sets	29	18	20	28	25	3
Total No. of Sets - 2005		**179**	**18**	**79**	**60**	**63**	**3**
Total No. of Sets		**270**	**54***	**79**	**60**	**63**	**11**

* Number of Replicates

** Net was lost in first trawl attempt

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Table 2 - Knik Arm Water Quality Data - 2004 and 2005

A. Water Quality by Beach Seine Station from North to South (all months combined)

Parameter		Station										All 120-Foot Beach Seine Stations
		KA1	**KA2**	**KA3**	**KA5**	**KA7**	**KA10**	**KA14**	**KA11**	**KA16**	**KA13**	
Temperature (deg. C)	**Mean**	9.1	15	10.8	3.9	8.2	10.1	9.6	7.8	8.8	9.1	9.8
	Max	9.1	15	14.2	7.6	16.6	15.8	17.3	16	16.6	16.2	17.3
	Min	9.1	15	7.4	0.2	0.1	-0.1	0.1	0.3	0.5	2.1	-0.1
	n	1	2	2	2	20	16	15	32	11	23	124
Salinity (ppt)	**Mean**	0.2	5.7	10.85	15.4	12.0	11.6	12.2	14.1	13.7	16.1	10.7
	Max	0.2	7	17.5	17.4	18.9	18.5	18.9	20	19.7	20.1	20.1
	Min	0.2	4.4	4.2	13.4	0.3	4.2	5.2	4.1	5.1	6.7	0.2
	n	1	2	2	2	20	16	15	32	11	23	124
Turbidity (NTU)	**Mean**	353	514	900	450	629	496.5	440.0	364.5	257.1	309.1	473.7
	Max*	353	573	900	450	1094	1000	1100	950	450	850	1100
	Min	353	455	900	450	282	259	31.6	58.6	73.7	65	32
	n	1	2	1	1	11	10	9	30	7	18	90

B. Water Quality by Month (all stations combined)**

Parameter		Month								All Months
		Apr	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	
Temperature (deg. C)	**Mean**	3.6	9.8	12.7	15.7	14.8	10.2	6.1	0.2	10.5
	Max	6.2	12.7	15.7	17.9	17.3	11.4	6.6	0.8	17.9
	Min	1.8	7.1	8.1	6	12.7	7.9	5.3	-0.1	-0.1
	n	24	50	52	40	7	15	12	10	210
Salinity (ppt)	**Mean**	19.1	16.4	8.7	6.1	5.0	9.0	10.9	13.4	11.5
	Max	20.1	19.8	14.9	15.7	7.6	10.2	11.8	13.9	20.1
	Min	17.2	10.6	0.1	3.5	3.2	8.1	10.3	12.5	0.1
	n	24	50	52	40	7	15	12	10	210
Turbidity (NTU)	**Mean**	523	377	280	511					389
	Max*	950	1094	831	1100	(No measurements taken)				1100
	Min	130	58.6	2.9	82.2					2.9
	n	18	50	61	39					168

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Notes: * Max turbidity meter reading is 1100 NTU

** Table 2B includes all sampling events (i.e., tow net, 30-foot beach seine, etc.)
July data are from 2005 only (no water quality data were collected in July 2004)

Table 3 - Total 2004 and 2005 Monthly Fish CPUE in the 120-Foot Beach Seine

	Total Catch		2004						2005				
Species	**No.**	**%**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Overall**	**Apr**	**May**	**Jun**	**Jul**	**Overall**
Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*)	267	6.9	1.1	0.4	0.0	0.1	0.0	0.3	0.2	1.6	3.2	0.6	1.3
Adult Chinook Salmon (*O. tshawytscha*)	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Chum Salmon (*O. keta*)	187	4.8	0.1	0.2	0.0	0.0	0.0	0.1	0.2	1.5	1.9	0.0	1.0
Adult Chum Salmon (*O. keta*)	2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Coho Salmon (*O. kisutch*)	332	8.6	1.1	0.5	0.2	0.2	0.4	0.5	0.6	1.3	2.3	3.9	1.6
Adult Coho Salmon (*O. kisutch*)	35	0.9	1.2	0.5	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.2	0.0
Juvenile Pink Salmon (*O. gorbuscha*)	33	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.2
Adult Pink Salmon (*O. gorbuscha*)	14	0.4	0.5	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.0
Juvenile Sockeye Salmon *(O. nerka)*	280	7.2	1.1	3.6	0.2	0.2	0.0	1.0	0.0	0.3	3.6	2.4	1.1
Adult Sockeye Salmon *(O. nerka)*	21	0.5	0.5	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.4	0.1
Rainbow Trout (*O. mykiss*)	4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Dolly Varden (*Salvelinus malma*)	2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bering Cisco (*Coregonus laurettae*)	9	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Longfin Smelt (*Spirinchus thaleichthys*)	527	13.6	1.4	0.5	1.4	6.6	1.2	2.3	0.0	0.8	6.1	3.1	1.8
Pacific Herring (*Clupea pallasi*)	51	1.3	0.0	0.0	0.4	0.5	0.0	0.2	0.0	0.3	0.2	0.0	0.2
Saffron Cod (*Eleginus gracilis*)	499	12.9	0.6	1.0	2.7	1.4	0.5	1.4	3.3	2.8	0.2	0.0	2.1
Ringtail Snailfish (*Liparis rutteri*)	43	1.1	0.0	0.0	0.2	1.9	0.1	0.5	0.2	0.2	0.0	0.0	0.1
Threespine Stickleback (*Gasterosteus aculeatus*)	1088	28.1	7.9	11.4	2.5	1.3	0.1	4.7	2.3	4.3	1.9	6.6	3.7
Ninespine Stickleback (*Pungitius pungitius*)	243	6.3	1.5	3.2	0.6	2.6	0.4	1.7	1.2	0.1	0.1	0.8	0.5
Pacific Staghorn Sculpin (*Leptocottus armatus*)	3	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Starry Flounder (*Platichthys stellatus*)	1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eulachon (*Thaleichthys pacificus*)	199	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.6	0.0	0.0	1.1
Tomcod (*Microgadus proximus)*	5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Walleye Pollock (*Theragra chalcogramma*)	3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified Flatfish	3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grand Total	**3876**	**100.0**	**17.2**	**21.3**	**8.4**	**14.6**	**2.7**	**13.4**	**8.2**	**16.2**	**19.7**	**18.8**	**14.9**
All Juvenile Salmonids	**1099**	**28.4**	**3.3**	**4.7**	**0.5**	**0.4**	**0.4**	**1.8**	**1.1**	**5.0**	**11.1**	**7.0**	**5.2**
Total Number of Sets	**270**	**n/a**	**19**	**17**	**25**	**20**	**10**	**91**	**47**	**74**	**29**	**29**	**179**

Table 4 - Total Fish Catch in 2004; 120-Foot Beach Seine

	Total Catch		Stations								
Species	**No.**	**%**	**KA1**	**KA3**	**KA5**	**KA7**	**KA10**	**KA11**	**KA13**	**KA 14**	**KA16**
Juvenile Chinook Salmon *(Oncorhynchus tshawytscha)*	28	2.3	0	0	0	2	9	8	3	2	4
Juvenile Chum Salmon *(O. keta)*	5	0.4	0	0	0	5	0	0	0	0	0
Adult Chum Salmon *(O. keta)*	1	0.1	0	0	0	0	0	0	0	1	0
Juvenile Coho Salmon *(O. kisutch)*	42	3.5	2	0	0	10	9	8	5	1	7
Adult Coho Salmon *(O. kisutch)*	30	2.5	0	0	0	6	12	6	1	3	2
Adult Pink Salmon *(O.gorbuscha)*	10	0.8	0	0	0	0	7	1	0	2	0
Juvenile Sockeye Salmon *(O. nerka)*	92	7.6	28	12	0	16	17	5	3	3	8
Adult Sockeye Salmon *(O. nerka)*	11	0.9	0	0	0	3	4	0	1	1	2
Bering Cisco *(Coregonus laurettae)*	4	0.3	0	0	0	0	2	0	0	0	2
Longfin Smelt *(Spirinchus thaleichthys)*	212	17.4	0	0	0	63	19	33	77	5	15
Pacific Herring *(Clupea harengus)*	19	1.6	0	0	0	5	2	2	5	1	4
Saffron Cod *(Eleginus gracilis)*	130	10.7	0	0	1	24	29	14	20	12	30
Ringtail Snailfish *(Liparis rutteri)*	43	3.5	0	0	0	27	8	3	0	5	0
Threespine Stickleback *(Gasterosteus aculeatus)*	153	12.6	15	4	2	69	23	9	13	9	9
Ninespine Stickleback *(Pungitius pungitius)*	432	35.5	27	6	0	184	98	45	21	31	20
Pacific Staghorn Sculpin *(Leptocottus armatus)*	3	0.2	0	0	0	1	0	0	0	2	0
Starry Flounder *(Platichthys stellatus)*	1	0.1	0	0	0	0	0	1	0	0	0
Grand Total	**1216**	**100.0**	**72**	**22**	**3**	**415**	**239**	**135**	**149**	**78**	**103**
All Juvenile Salmonids	**167**	**13.7**	**30**	**12.0**	**0**	**33**	**35**	**21**	**11**	**6**	**19**
Total Number of Sets	**91**	**n/a**	**1**	**2.0**	**1**	**17**	**15**	**19**	**10**	**14**	**12**

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Table 5 - Fish CPUE in 2004; 120-Foot Beach Seine

		Stations								
Species	**Total CPUE***	**KA1**	**KA3**	**KA5**	**KA7**	**KA10**	**KA11**	**KA13**	**KA14**	**KA16**
Juvenile Chinook Salmon *(Oncorhynchus tshawytscha)*	0.3	0.0	0.0	0.0	0.1	0.6	0.4	0.3	0.1	0.3
Juvenile Chum Salmon *(O. keta)*	0.1	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Adult Chum Salmon *(O. keta)*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Juvenile Coho Salmon *(O. kisutch)*	0.5	2.0	0.0	0.0	0.6	0.6	0.4	0.5	0.1	0.6
Adult Coho Salmon *(O. kisutch)*	0.3	0.0	0.0	0.0	0.4	0.8	0.3	0.1	0.2	0.2
Adult Pink Salmon *(O.gorbuscha)*	0.1	0.0	0.0	0.0	0.0	0.5	0.1	0.0	0.1	0.0
Juvenile Sockeye Salmon *(O. nerka)*	1.0	28.0	6.0	0.0	0.9	1.1	0.3	0.3	0.2	0.7
Adult Sockeye Salmon *(O. nerka)*	0.1	0.0	0.0	0.0	0.2	0.3	0.0	0.1	0.1	0.2
Bering Cisco *(Coregonus laurettae)*	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2
Longfin Smelt *(Spirinchus thaleichthys)*	2.3	0.0	0.0	0.0	3.7	1.3	1.7	7.7	0.4	1.3
Pacific Herring *(Clupea harengus)*	0.2	0.0	0.0	0.0	0.3	0.1	0.1	0.5	0.1	0.3
Saffron Cod *(Eleginus gracilis)*	1.4	0.0	0.0	1.0	1.4	1.9	0.7	2.0	0.9	2.5
Ringtail Snailfish *(Liparis rutteri)*	0.5	0.0	0.0	0.0	1.6	0.5	0.2	0.0	0.4	0.0
Threespine Stickleback *(Gasterosteus aculeatus)*	4.7	27.0	3.0	0.0	10.8	6.5	2.4	2.1	2.2	1.7
Ninespine Stickleback *(Pungitius pungitius)*	1.7	15.0	2.0	2.0	4.1	1.5	0.5	1.3	0.6	0.8
Pacific Staghorn Sculpin *(Leptocottus armatus)*	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
Starry Flounder *(Platichthys stellatus)*	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Grand Total	**13.4**	**72.0**	**11.0**	**3.0**	**24.4**	**15.9**	**7.1**	**14.9**	**5.6**	**8.6**
All Juvenile Salmonids	**1.8**	**30.0**	**6.0**	**0.0**	**1.9**	**2.3**	**1.1**	**1.1**	**0.4**	**1.6**
Total Number of Sets	**91**	**1**	**2**	**1**	**17**	**15**	**19**	**10**	**14**	**12**

* CPUE: Catch per beach seine set

Table 6 - Total Fish Catch in 2005; 120-Foot Beach Seine

	Stations												
Species	**Total Catch**	**Overall %**	**KA 1**	**KA 2**	**KA 3**	**KA 5**	**KA 6**	**KA 7**	**KA 10**	**KA 11**	**KA 13**	**KA 14**	**KA 16**
Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*)	239	9.0	5	4	1	1	2	30	31	66	55	24	20
Adult Chinook Salmon (*O. tshawytscha*)	1	0.0	0	0	0	0	0	0	0	1	0	0	0
Juvenile Chum Salmon (*O. keta*)	182	6.8	13	1	8	6	1	19	9	32	61	15	17
Adult Chum Salmon (*O. keta*)	1	0.0	0	0	0	0	0	0	0	0	0	1	0
Juvenile Coho Salmon (*O. kisutch*)	291	10.9	12	2	6	4	7	32	50	67	31	45	35
Adult Coho Salmon (*O. kisutch*)	4	0.2	0	0	0	0	0	0	0	1	0	3	0
Juvenile Pink Salmon (*O. gorbuscha*)	33	1.2	0	0	0	0	0	7	2	7	13	3	1
Adult Pink Salmon (*O. gorbuscha*)	4	0	0	0	0	0	0	0	0	4	0	0	0
Juvenile Sockeye Salmon *(O. nerka)*	188	7.1	34	3	5	1	7	36	31	10	18	24	19
Adult Sockeye Salmon *(O. nerka)*	10	0.4	4	0	0	0	0	1	0	3	0	1	1
Rainbow Trout (O. mykiss)	4	0.2	0	0	0	0	0	0	1	2	0	0	1
Dolly Varden (*Salvelinus malma*)	2	0.1	0	0	0	0	0	1	0	0	0	1	0
Bering Cisco (*Coregonus laurettae*)	5	0.2	0	0	0	0	0	0	0	1	0	0	4
Longfin Smelt (*Spirinchus thaleichthys*)	314	11.8	1	1	0	0	3	11	18	43	194	5	38
Pacific Herring (*Clupea pallasi*)	32	1.2	0	0	0	0	0	1	3	5	18	0	5
Saffron Cod (*Eleginus gracilis*)	369	13.9	1	0	2	0	1	17	160	13	82	74	19
Ringtail Snailfish (*Liparis rutteri*)	24	0.9	0	0	0	1	0	1	2	0	19	1	0
Threespine Stickleback (*Gasterosteus aculeatus*)	656	24.7	28	7	27	76	5	117	86	79	131	61	39
Ninespine Stickleback (*Pungitius pungitius*)	90	3.4	1	3	0	1	0	10	5	19	35	11	5
Tomcod (*Microgadus proximus)*	5	0.2	0	0	0	0	0	0	3	0	2	0	0
Unidentified Flatfish	3	0.1	0	0	0	0	0	1	0	0	1	0	1
Eulachon (*Thaleichthys pacificus*)	199	7.5	0	0	1	0	0	12	32	31	9	20	94
Walleye Pollock (*Theragra chalcogramma*)	3	0.1	0	0	0	0	0	0	0	0	2	0	1
Grand Total	**2659**	**100.0**	**99**	**21**	**50**	**90**	**26**	**296**	**433**	**384**	**671**	**289**	**300**
All Juvenile Salmonids	**933**	**35**	**64**	**10**	**20**	**12**	**17**	**124**	**123**	**182**	**178**	**111**	**92**
Total Number of Sets	**179**	**n/a**	**4**	**4**	**6**	**2**	**2**	**26**	**19**	**47**	**37**	**17**	**15**

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Table 7 - Fish CPUE in 2005; 120-Foot Beach Seine

	Stations											
Species	**Total CPUE**	**KA1**	**KA2**	**KA3**	**KA5**	**KA6**	**KA7**	**KA10**	**KA11**	**KA13**	**KA14**	**KA16**
Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*)	1.3	1.3	1.0	0.2	0.5	1.0	1.2	1.6	1.4	1.5	1.4	1.3
Adult Chinook Salmon (*O. tshawytscha*)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Chum Salmon (*O. keta*)	1.0	3.3	0.3	1.3	3.0	0.5	0.7	0.5	0.7	1.6	0.9	1.1
Adult Chum Salmon (*O. keta*)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Juvenile Coho Salmon (*O. kisutch*)	1.6	3.0	0.5	1.0	2.0	3.5	1.2	2.6	1.4	0.8	2.6	2.3
Adult Coho Salmon (*O. kisutch*)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Juvenile Pink Salmon (*O. gorbuscha*)	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.1	0.4	0.2	0.1
Adult Pink Salmon (*O. gorbuscha*)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Juvenile Sockeye Salmon *(O. nerka)*	1.1	8.5	0.8	0.8	0.5	3.5	1.4	1.6	0.2	0.5	1.4	1.3
Adult Sockeye Salmon *(O. nerka)*	0.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1
Rainbow Trout (*O. mykiss*)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1
Dolly Varden (*Salvelinus malma*)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Bering Cisco (*Coregonus laurettae*)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Longfin Smelt (*Spirinchus thaleichthys*)	1.8	0.3	0.3	0.0	0.0	1.5	0.4	0.9	0.9	5.2	0.3	2.5
Pacific Herring (*Clupea pallasi*)	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.5	0.0	0.3
Saffron Cod (*Eleginus gracilis*)	2.1	0.3	0.0	0.3	0.0	0.5	0.7	8.4	0.3	2.2	4.4	1.3
Ringtail Snailfish (*Liparis rutteri*)	0.1	0.0	0.0	0.0	0.5	0.0	0.0	0.1	0.0	0.5	0.1	0.0
Threespine Stickleback (*Gasterosteus aculeatus*)	3.7	7.0	1.8	4.5	38.0	2.5	4.5	4.5	1.7	3.5	3.6	2.6
Ninespine Stickleback (*Pungitius pungitius*)	0.5	0.3	0.8	0.0	0.5	0.0	0.4	0.3	0.4	0.9	0.6	0.3
Tomcod (*Microgadus proximus)*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0
Unidentified Flatfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Eulachon (*Thaleichthys pacificus*)	1.1	0.0	0.0	0.2	0.0	0.0	0.5	1.7	0.7	0.2	1.2	6.3
Walleye Pollack (*Theragra chalcogramma*)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
Grand Total	**14.9**	**24.8**	**5.3**	**8.3**	**45.0**	**13.0**	**11.4**	**22.8**	**8.2**	**18.1**	**17.0**	**20.0**
All Juvenile Salmonids	**5.2**	**16.0**	**2.5**	**3.3**	**6.0**	**8.5**	**4.8**	**6.5**	**3.9**	**4.8**	**6.5**	**6.1**
Total Number of Sets	**179**	**4**	**4**	**6**	**2**	**2**	**26**	**19**	**47**	**37**	**17**	**15**

00214\012\Final Report 11-30-2005\Tables\Table 7

	Mean CPUE for	
Geographic Summary*	**East Side**	**West Side**
Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*)	1.2	1.3
Juvenile Chum Salmon (*O. keta*)	1.0	0.8
Juvenile Coho Salmon (*O. kisutch*)	1.3	2.0
Juvenile Pink Salmon (*O. gorbuscha*)	0.4	0.4
Juvenile Sockeye Salmon *(O. nerka)*	1.0	1.4

Notes:

* West side includes all odd-numbered stations
East side includes all even-numbered stations

Table 8 - Statistical Analyses of Fish CPUE in 2005; 120-Foot Beach Seine

Variable	Taxon	Statistic	df	Significance
Station		**Chi-Square**		
	Adult salmon	14.88	10	0.136
	All Juvenile Salmon	6.49	10	0.773
	Juvenile Chinook	4.51	10	0.921
	Juvenile Chum	7.36	10	0.691
	Juvenile Coho	11.07	10	0.352
	Juvenile Pink	6.82	10	0.742
	Juvenile Sockeye	19.90	10	**0.030**
	Eulachon	4.70	10	0.911
	Herring	18.00	10	0.055
	Saffron	21.85	10	**0.016**
	Longfin Smelt	8.70	10	0.561
	All Sticklebacks*	18.35	10	**0.049**
	All Fish	15.76	10	0.107
Tide		**Chi-Square**	**df**	**Significance**
	Adult salmon	2.11	3	0.549
	All Juvenile Salmon	7.22	3	0.065
	Juvenile Chinook	6.26	3	0.100
	Juvenile Chum	4.84	3	0.184
	Juvenile Coho	12.14	3	**0.007**
	Juvenile Pink	5.08	3	0.166
	Juvenile Sockeye	16.58	3	**0.001**
	Eulachon	7.29	3	0.063
	Herring	3.52	3	0.318
	Saffron	9.45	3	**0.024**
	Longfin Smelt	5.18	3	0.159
	All Sticklebacks*	2.75	3	0.432
	All Fish	4.36	3	0.225
Month		**Chi-Square**	**df**	**Significance**
	Adult salmon	25.74	3	**0.000**
	All Juvenile Salmon	33.07	3	**0.000**
	Juvenile Chinook	22.85	3	**0.000**
	Juvenile Chum	36.05	3	**0.000**
	Juvenile Coho	15.79	3	**0.001**
	Juvenile Pink	18.72	3	**0.000**
	Juvenile Sockeye	41.34	3	**0.000**
	Eulachon	41.69	3	**0.000**
	Herring	14.05	3	**0.003**
	Saffron	37.58	3	**0.000**
	Longfin Smelt	17.47	3	**0.001**
	All Sticklebacks*	8.82	3	**0.032**
	All Fish	8.67	3	**0.034**

* Threespine and Ninespine combined

df = Degrees of Freedom

Table 9 - Fish CPUE in 2005 as a Function of Tide; 120-Foot Beach Seine

	CPUE				
Species	**Ebb**	**Low Slack**	**Flood**	**High Slack**	**Total**
Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*)	0.8	7.0	1.4	1.3	1.3
Adult Chinook Salmon (*O. tshawytscha*)	0.0	0.0	0.0	0.0	0.0
Juvenile Chum Salmon (*O. keta*)	0.8	2.4	1.2	0.6	1.0
Adult Chum Salmon (*O. keta*)	0.0	0.0	0.0	0.0	0.0
Juvenile Coho Salmon (*O. kisutch*)	1.1	0.3	2.4	3.3	1.6
Adult Coho Salmon (*O. kisutch*)	0.0	0.0	0.0	0.0	0.0
Juvenile Pink Salmon (*O.gorbuscha*)	0.2	0.4	0.1	0.0	0.2
Adult Pink Salmon (*O. gorbuscha*)	0.0	0.0	0.0	0.0	0.0
Juvenile Sockeye Salmon (*O. nerka*)	0.4	1.8	2.0	2.1	1.1
Adult Sockeye Salmon *(O. nerka)*	0.0	0.0	0.1	0.4	0.1
Rainbow Trout (*O. mykiss*)	0.0	0.0	0.0	0.3	0.0
Dolly Varden (*Salvelinus malma*)	0.0	0.0	0.0	0.0	0.0
Bering Cisco (*Coregonus laurettae*)	0.0	0.0	0.1	0.0	0.0
Longfin Smelt (*Spirinchus thaleichthys*)	1.2	10.4	1.5	2.5	1.8
Pacific Herring (*Clupea pallasi*)	0.2	0.3	0.1	0.4	0.2
Saffron Cod (*Eleginus gracilis*)	2.6	0.8	1.6	0.0	2.1
Ringtail Snailfish (*Liparis rutteri*)	0.2	0.0	0.0	0.0	0.1
Threespine Stickleback (*Gasterosteus aculeatus*)	3.1	2.0	3.8	11.3	3.7
Ninespine Stickleback (*Pungitius pungitius*)	0.5	0.0	0.5	0.8	0.5
Unidentified Flatfish	0.0	0.0	0.0	0.0	0.0
Eulachon (*Thaleichthys pacificus*)	1.4	0.0	0.9	0.0	1.1
Tomcod (*Microgadus proximus)*	0.0	0.0	0.0	0.0	0.0
Walleye Pollack (*Theragra chalcogramma*)	0.0	0.0	0.0	0.0	0.0
Grand Total	**12.9**	**25.1**	**15.8**	**22.8**	**14.9**
All Juvenile Salmonids	**3.4**	**11.8**	**7.1**	**7.3**	**5.2**
No. of Sets	**102**	**8**	**61**	**8**	**179**

Table 10 - Total Fish Catch by Tow Net; May through July 2005

	Total Catch		Transect 1						Transect 2						Transect 3					
			Station						Station						Station					
Species	**No.**	**%**	**1**	**2**	**3**	**4**	**5**	**Sum**	**1**	**2**	**3**	**4**	**5**	**Sum**	**1**	**2**	**3**	**4**	**5**	**Sum**
Juvenile Chinook Salmon *(O. tshawytscha)*	16	0.7	1	0	1	0	1	3	0	0	2	0	1	3	0	0	2	1	1	4
Juvenile Chum Salmon *(O. keta)*	197	9.0	10	4	4	10	10	38	11	8	13	25	23	80	1	6	24	16	2	49
Juvenile Coho Salmon *(O. kisutch)*	21	1.0	1	0	2	1	3	7	0	0	0	2	2	4	0	1	4	0	0	5
Juvenile Pink Salmon *(O. gorbuscha)*	102	4.7	5	5	5	9	8	32	8	8	4	5	7	32	1	3	9	10	4	27
Juvenile Sockeye Salmon *(O. nerka)*	192	8.8	22	10	12	7	20	71	5	4	7	2	14	32	2	2	22	17	7	50
Longfin Smelt *(Spirinchus thaleichthys)*	7	0.3	0	0	0	1	0	1	1	0	0	0	0	1	0	1	0	2	1	4
Pacific Herring *(Clupea harengus)*	41	1.9	1	3	0	0	2	6	2	1	0	2	1	6	0	1	1	21	0	23
Saffron Cod *(Eleginus gracilis)*	3	0.1	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1
Eulachon *(Thaleichthys pacificus)*	8	0.4	0	1	1	0	0	2	1	1	0	0	0	2	1	0	0	0	0	1
Threespine Stickleback *(Gasterosteus aculeatus)*	1535	70.4	1	1	4	29	10	45	193	23	54	26	138	434	67	41	55	403	354	920
Ninespine Stickleback *(Pungitius pungitius)*	28	1.3	2	0	0	0	0	2	13	0	0	2	1	16	6	1	0	0	1	8
Snake Prickleback *(Lumpenus sagitta)*	1	0.0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Unidentified Larval Fish	25	1.1	0	0	0	1	0	1	0	2	4	0	2	8	0	0	0	10	0	10
Unidentified Flatfish	4	0.2	1	0	0	0	0	1	0	0	0	1	1	2	1	0	0	0	0	1
Grand Total	**2180**	**100.0**	**46**	**26**	**32**	**63**	**59**	**211**	**235**	**49**	**87**	**69**	**195**	**620**	**80**	**59**	**120**	**484**	**375**	**1103**
All Juvenile Salmonids	**528**	**24.2**	**39**	**19**	**24**	**27**	**42**	**151**	**24**	**20**	**26**	**34**	**47**	**151**	**4**	**12**	**61**	**44**	**14**	**135**
Total Number of Sets	**79**		**3**	**3**	**3**	**3**	**3**	**15**	**5**	**4**	**4**	**4**	**4**	**21**	**4**	**4**	**4**	**4**	**4**	**20**

	Transect 4						Transect 5				Transect 6		
	Station						Station				Station		
Species	**1**	**2**	**3**	**4**	**5**	**Sum**	**1**	**2**	**3**	**Sum**	**1**	**2**	**Sum**
Juvenile Chinook Salmon *(O. tshawytscha)*	0	0	5	0	0	5	0	0	1	1	0	0	0
Juvenile Chum Salmon *(O. keta)*	2	5	3	3	2	15	11	2	2	15	1	0	1
Juvenile Coho Salmon *(O. kisutch)*	0	0	1	0	2	3	0	0	2	2	0	0	0
Juvenile Pink Salmon *(O. gorbuscha)*	1	3	2	0	0	6	1	4	0	5	1	0	1
Juvenile Sockeye Salmon *(O. nerka)*	1	6	2	10	10	29	0	1	9	10	1	1	2
Longfin Smelt *(Spirinchus thaleichthys)*	0	0	1	0	0	1	0	0	0	0	0	0	0
Pacific Herring *(Clupea harengus)*	0	2	0	2	2	6	0	0	0	0	0	0	0
Saffron Cod *(Eleginus gracilis)*	0	1	0	0	0	1	0	0	0	0	0	0	0
Eulachon *(Thaleichthys pacificus)*	0	0	0	0	2	2	1	0	0	1	0	0	0
Threespine Stickleback *(Gasterosteus aculeatus)*	4	9	42	25	56	136	0	0	0	0	0	1	1
Ninespine Stickleback *(Pungitius pungitius)*	0	0	0	2	0	2	0	0	0	0	0	0	0
Snake Prickleback *(Lumpenus sagitta)*	0	0	0	0	0	0	0	0	0	0	0	0	0
Unidentified Larval Fish	2	1	1	0	2	6	0	0	0	0	0	0	0
Unidentified Flatfish	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	**11**	**29**	**60**	**46**	**81**	**212**	**14**	**9**	**17**	**34**	**4**	**4**	**5**
All Juvenile Salmonids	**4**	**14**	**13**	**13**	**14**	**58**	**12**	**7**	**14**	**33**	**3**	**1**	**4**
Total Number of Sets	**3**	**4**	**4**	**3**	**3**	**17**	**2**	**1**	**1**	**4**	**1**	**1**	**2**

Table 11 - Total Fish CPUE by Tow Net; May through July 2005

		Transect 1						Transect 2						Transect 3					
	Total	Station						Station						Station					
Species	**CPUE**	**1**	**2**	**3**	**4**	**5**	**Sum**	**1**	**2**	**3**	**4**	**5**	**Sum**	**1**	**2**	**3**	**4**	**5**	**Sum**
Juvenile Chinook Salmon *(O. tshawytscha)*	0.2	0.3	0.0	0.3	0.0	0.3	0.2	0.0	0.0	0.5	0.0	0.3	0.1	0.0	0.0	0.5	0.3	0.3	0.2
Juvenile Chum Salmon *(O. keta)*	2.5	3.3	1.3	1.3	3.3	3.3	2.5	2.2	2.0	3.3	6.3	5.8	3.8	0.3	1.5	6.0	4.0	0.5	2.5
Juvenile Coho Salmon *(O. kisutch)*	0.3	0.3	0.0	0.7	0.3	1.0	0.5	0.0	0.0	0.0	0.5	0.5	0.2	0.0	0.3	1.0	0.0	0.0	0.3
Juvenile Pink Salmon *(O. gorbuscha)*	1.3	1.7	1.7	1.7	3.0	2.7	2.1	1.6	2.0	1.0	1.3	1.8	1.5	0.3	0.8	2.3	2.5	1.0	1.4
Juvenile Sockeye Salmon *(O. nerka)*	2.4	7.3	3.3	4.0	2.3	6.7	4.7	1.0	1.0	1.8	0.5	3.5	1.5	0.5	0.5	5.5	4.3	1.8	2.5
Longfin Smelt *(Spirinchus thaleichthys)*	0.1	0.0	0.0	0.0	0.3	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.5	0.3	0.2
Pacific Herring *(Clupea harengus)*	0.5	0.3	1.0	0.0	0.0	0.7	0.4	0.4	0.3	0.0	0.5	0.3	0.3	0.0	0.3	0.3	5.3	0.0	1.2
Saffron Cod *(Eleginus gracilis)*	0.0	0.3	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.1
Eulachon *(Thaleichthys pacificus)*	0.1	0.0	0.3	0.3	0.0	0.0	0.1	0.2	0.3	0.0	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.0	0.1
Threespine Stickleback *(Gasterosteus aculeatus)*	19.4	0.3	0.3	1.3	9.7	3.3	3.0	38.6	5.8	13.5	6.5	34.5	20.7	16.8	10.3	13.8	100.8	88.5	46.0
Ninespine Stickleback *(Pungitius pungitius)*	0.4	0.7	0.0	0.0	0.0	0.0	0.1	2.6	0.0	0.0	0.5	0.3	0.8	1.5	0.3	0.0	0.0	0.3	0.4
Snake Prickleback *(Lumpenus sagitta)*	0.0	0.0	0.0	0.0	0.3	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified Larval Fish	0.3	0.0	0.0	0.0	0.3	0.0	0.1	0.0	0.5	1.0	0.0	0.5	0.4	0.0	0.0	0.0	2.5	0.0	0.5
Unidentified Flatfish	0.1	0.3	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.3	0.3	0.1	0.3	0.0	0.0	0.0	0.0	0.1
Grand Total	**27.6**	**15.3**	**8.7**	**10.7**	**21.0**	**19.7**	**14.1**	**47.0**	**12.3**	**21.8**	**17.3**	**48.8**	**29.5**	**20.0**	**14.8**	**30.0**	**121.0**	**93.8**	**55.2**
All Juvenile Salmonids	**6.7**	**13.0**	**6.3**	**8.0**	**9.0**	**14.0**	**10.1**	**4.8**	**5.0**	**6.5**	**8.5**	**11.8**	**7.2**	**1.0**	**3.0**	**15.3**	**11.0**	**3.5**	**6.8**
Total Number of Sets	**6.7**	**3**	**3**	**3**	**3**	**3**	**15**	**5**	**4**	**4**	**4**	**4**	**21**	**4**	**4**	**4**	**4**	**4**	**20**

	Transect 4						Transect 5				Transect 6		
	Station						Station				Station		
Species	**1**	**2**	**3**	**4**	**5**	**Sum**	**1**	**2**	**3**	**Sum**	**1**	**2**	**Sum**
Juvenile Chinook Salmon *(O. tshawytscha)*	0.0	0.0	1.3	0.0	0.0	0.3	0.0	0.0	1.0	0.3	0.0	0.0	0.0
Juvenile Chum Salmon *(O. keta)*	0.7	1.3	0.8	1.0	0.7	0.9	5.5	2.0	2.0	3.8	1.0	0.0	0.5
Juvenile Coho Salmon *(O. kisutch)*	0.0	0.0	0.3	0.0	0.7	0.2	0.0	0.0	2.0	0.5	0.0	0.0	0.0
Juvenile Pink Salmon *(O. gorbuscha)*	0.3	0.8	0.5	0.0	0.0	0.4	0.5	4.0	0.0	1.3	1.0	0.0	0.5
Juvenile Sockeye Salmon *(O. nerka)*	0.3	1.5	0.5	3.3	3.3	1.7	0.0	1.0	9.0	2.5	1.0	1.0	1.0
Longfin Smelt *(Spirinchus thaleichthys)*	0.0	0.0	0.3	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pacific Herring *(Clupea harengus)*	0.0	0.5	0.0	0.7	0.7	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Saffron Cod *(Eleginus gracilis)*	0.0	0.3	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eulachon *(Thaleichthys pacificus)*	0.0	0.0	0.0	0.0	0.7	0.1	0.5	0.0	0.0	0.3	0.0	0.0	0.0
Threespine Stickleback *(Gasterosteus aculeatus)*	1.3	2.3	10.5	8.3	18.7	8.0	0.0	0.0	0.0	0.0	0.0	1.0	0.5
Ninespine Stickleback *(Pungitius pungitius)*	0.0	0.0	0.0	0.7	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Snake Prickleback *(Lumpenus sagitta)*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified Larval Fish	0.7	0.3	0.3	0.0	0.7	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified Flatfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grand Total	**3.7**	**7.3**	**15.0**	**15.3**	**27.0**	**12.5**	**7.0**	**9.0**	**17.0**	**8.5**	**4.0**	**4.0**	**2.5**
All Juvenile Salmonids	**1.3**	**3.5**	**3.3**	**4.3**	**4.7**	**3.4**	**6.0**	**7.0**	**14.0**	**8.3**	**3.0**	**1.0**	**2.0**
Total Number of Sets	**3.0**	**4.0**	**4.0**	**3.0**	**3.0**	**17.0**	**2.0**	**1.0**	**1.0**	**4.0**	**1.0**	**1.0**	**2.0**

Table 12 - Statistical Analyses of Fish CPUE in the Tow Net

Variable	Taxon	Statistic	df	Significance
		Chi-Square		
Month	All Juvenile Salmon	32.17	2	**0.000**
	Juvenile Chinook	8.79	2	**0.012**
	Juvenile Chum	41.89	2	**0.000**
	Juvenile Coho	3.90	2	0.143
	Juvenile Pink	32.88	2	**0.000**
	Juvenile Sockeye	22.68	2	**0.000**
	Herring	3.07	2	0.215
	All Sticklebacks*	52.98	2	**0.000**
	All fish	2.46	2	0.292
Transect		**Chi-Square**	**df**	
	All Juvenile Salmon	4.63	5	0.462
	Juvenile Chinook	1.08	5	0.956
	Juvenile Chum	4.28	5	0.509
	Juvenile Coho	2.85	5	0.723
	Juvenile Pink	5.11	5	0.402
	Juvenile Sockeye	5.46	5	0.362
	Herring	1.95	5	0.856
	All Sticklebacks*	2.66	5	0.752
	All fish	4.31	5	0.506
Central Arm v.		**Mann-Whitney U**	**Z**	
Nearshore	All Juvenile Salmon	659	-0.50	0.619
Stations**	Juvenile Chinook	679	-0.43	0.666
	Juvenile Chum	693	-0.15	0.882
	Juvenile Coho	699	-0.09	0.927
	Juvenile Pink	666	-0.48	0.633
	Juvenile Sockeye	661	-0.54	0.592
	Herring	699	-0.09	0.927
	All Sticklebacks*	698	-0.09	0.926
	All fish	692	-0.14	0.889

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* Threespine and ninespine combined
** "Central Arm" includes Stations 2, 3, and 4; "Nearshore" includes Stations 1 and 5 (See Figure 3)

df = Degrees of Freedom
Z = Critical Value

Table 13 - Total Catch and CPUE in 2005 by Fixed Tow Net at Port MacKenzie

	Station						All Stations		
	PM 00		PM 01		PM 02				
Species	**No.**	**CPUE**	**No.**	**CPUE**	**No.**	**CPUE**	**No.**	**% Total**	**CPUE**
Juvenile Chinook Salmon *(O. tshawytscha)*	8	0.4	3	0.3	8	0.2	19	2.5	0.3
Juvenile Chum Salmon *(O. keta)*	20	1.0	7	0.7	43	1.3	70	9.2	1.1
Juvenile Coho Salmon *(O. kisutch)*	23	1.2	14	1.4	95	2.9	132	17.3	2.1
Juvenile Pink Salmon *(O. gorbuscha)*	1	0.1	0	0.0	4	0.1	5	0.7	0.1
Juvenile Sockeye Salmon *(O. nerka)*	49	2.5	27	2.7	80	2.4	156	20.4	2.5
Bering Cisco (*Coregonus laurettae*)	3	0.2	4	0.4	0	0.0	7	0.9	0.1
Threespine Stickleback *(Gasterosteus aculeatus)*	118	5.9	22	2.2	155	4.7	295	38.6	4.7
Ninespine Stickleback *(Pungitius pungitius)*	5	0.3	0	0.0	6	0.2	11	1.4	0.2
Longfin Smelt (*Spirinchus thaleichthys*)	3	0.2	0	0.0	1	0.0	4	0.5	0.1
Unidentified Larval Fish	0	0.0	1	0.1	0	0.0	1	0.1	0.0
Grand Total	**230**	**11.5**	**86**	**7.8**	**448**	**11.9**	**764**	**100.0**	**11.1**
Total Juvenile Salmonids	**101**	**5.1**	**51**	**5.1**	**230**	**7.0**	**382**	**50.0**	**6.1**
Total No. of Sets	**20**		**10**		**33**		**63**	**n/a**	

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Table 14 - Statistical Analyses of Fish CPUE in the Fixed Tow Net

Variable	Taxon	Statistic	df	Significance
Station		**Chi-Square**		
	All Juvenile Salmon	0.06	2	0.969
	Juvenile Chinook	0.31	2	0.855
	Juvenile Chum	0.29	2	0.865
	Juvenile Coho	0.86	2	0.650
	Juvenile Sockeye	0.01	2	0.995
	Longfin Smelt	3.41	2	0.181
	All Sticklebacks*	0.50	2	0.779
	All fish	0.38	2	0.827
Tide		**Chi-Square**		
	Juvenile Salmonids	5.75	2	0.056
	Chinook	0.72	2	0.699
	Juvenile Chum	9.60	2	**0.008**
	Juvenile Coho	7.15	2	**0.028**
	Juvenile Sockeye	5.65	2	0.059
	Longfin Smelt	11.01	2	**0.004**
	All Sticklebacks*	11.40	2	**0.003**
	All fish	3.36	2	0.186
Month		**Mann-Whitney U**	**Z**	
	All Juvenile Salmon	24	-2.546	**0.010**
	Juvenile Chinook	64.5	-0.034	0.976
	Juvenile Chum	7	-3.764	**0.000**
	Juvenile Coho	16.5	-3.053	**0.002**
	Juvenile Sockeye	35.5	-1.844	0.067
	Longfin Smelt	56.5	-0.802	0.605
	All Sticklebacks*	18	-3.091	**0.003**
	All fish	58.5	-0.404	0.693

* Threespine and Ninespine combined

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df = Degrees of Freedom
Z = Critical Value

Table 15 - Total Fish Catch in 2005 in Port MacKenzie 30-foot Beach Seines

	Total Catch		Stations							
Species	**No.**	**%**	**PM N1**	**PM N2**	**PM N3**	**PM S1**	**PM S2**	**PM S3**	**PM S4**	**PM SS**
Juvenile Chinook Salmon *(Oncorhynchus tshawytscha)*	5	0.7	3	2	0	0	0	0	0	0
Juvenile Chum Salmon *(O. keta)*	18	2.3	14	2	0	2	0	0	0	0
Juvenile Coho Salmon *(O. kisutch)*	173	22.5	88	15	4	32	1	16	1	16
Juvenile Pink Salmon *(O. gorbuscha)*	4	0.5	2	0	0	1	0	1	0	0
Juvenile Sockeye Salmon *(O. nerka)*	122	15.9	36	6	7	68	1	1	1	2
Juvenile Rainbow Trout *(O. mykiss)*	1	0.1	0	0	0	1	0	0	0	0
Bering Cisco *(Coregonus laurettae)*	9	1.2	4	0	1	1	0	3	0	0
Longfin Smelt *(Spirinchus thaleichthys)*	116	15.1	8	1	3	103	0	0	0	1
Saffron Cod *(Eleginus gracilis)*	2	0.3	0	0	0	1	0	1	0	0
Pacific Herring *(Clupea harengus)*	1	0.1	0	0	0	0	0	1	0	0
Threespine Stickleback *(Gasterosteus aculeatus)*	297	38.6	157	21	29	83	0	3	4	0
Ninespine Stickleback *(Pungitius pungitius)*	18	2.3	4	2	9	1	0	1	1	0
Unidentified Larval Fish	1	0.1	0	0	1	0	0	0	0	0
Pacific Staghorn Sculpin *(Leptocottus armatus)*	1	0.1	1	0	0	0	0	0	0	0
Starry Flounder *(Platichthys stellatus)*	1	0.1	1	0	0	0	0	0	0	0
Grand Total	**769**	**100.0**	**318**	**49**	**54**	**293**	**2**	**27**	**7**	**19**
Total Juvenile Salmonids	**322**	**41.9**	**143**	**25**	**11**	**104**	**2**	**21**	**2**	**18**
Total Number of Sets	**60**	**n/a**	**18**	**5**	**7**	**18**	**2**	**7**	**2**	**1**

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Table 16 - Fish CPUE in 2005 in Port MacKenzie 30-Foot Beach Seines

Species	Total CPUE	Stations							
		N1	N2	N3	S1	S2	S3	S4	SS
Juvenile Chinook Salmon *(Oncorhynchus tshawytscha)*	0.1	0.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Juvenile Chum Salmon *(O. keta)*	0.3	0.8	0.4	0.0	0.1	0.0	0.0	0.0	0.0
Juvenile Coho Salmon *(O. kisutch)*	2.9	4.9	3.0	0.6	1.8	0.5	2.3	0.5	16.0
Juvenile Pink Salmon *(O. gorbuscha)*	0.1	0.1	0.0	0.0	0.1	0.0	0.1	0.0	0.0
Juvenile Sockeye Salmon *(O. nerka)*	2.0	2.0	1.2	1.0	3.8	0.5	0.1	0.5	2.0
Juvenile Rainbow Trout *(O. mykiss)*	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Bering Cisco *(Coregonus laurettae)*	0.2	0.2	0.0	0.1	0.1	0.0	0.4	0.0	0.0
Longfin Smelt *(Spirinchus thaleichthys)*	1.9	0.4	0.2	0.4	5.7	0.0	0.0	0.0	1.0
Saffron Cod *(Eleginus gracilis)*	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0
Pacific Herring *(Clupea harengus)*	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Threespine Stickleback *(Gasterosteus aculeatus)*	5.0	8.7	4.2	4.1	4.6	0.0	0.4	2.0	0.0
Ninespine Stickleback *(Pungitius pungitius)*	0.3	0.2	0.4	1.3	0.1	0.0	0.1	0.5	0.0
Unidentified Larval Fish	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Pacific Staghorn Sculpin *(Leptocottus armatus)*	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Starry Flounder *(Platichthys stellatus)*	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grand Total	**12.8**	**17.7**	**9.8**	**7.7**	**16.3**	**1.0**	**3.9**	**3.5**	**19.0**
Total Juvenile Salmonids	**5.4**	**7.9**	**5.0**	**1.6**	**5.7**	**1.0**	**2.6**	**1.0**	**18.0**
Total Number of Sets	**60**	**18**	**5**	**7**	**18**	**2**	**7**	**2**	**1**

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Table 17 - Statistical Analyses of CPUE in Port MacKenzie 30-Foot Beach Seines

Variable	Taxa	Statistic	df	Significance
Tide		**Chi-Square**		
	All Juvenile Salmon	8.02	3	0.046
	Juvenile Chinook	1.39	3	0.709
	Juvenile Chum	13.25	3	**0.004**
	Juvenile Coho	2.09	3	0.554
	Juvenile Sockeye	8.38	3	**0.039**
	Longfin Smelt	1.62	3	0.656
	All Sticklebacks*	12.72	3	**0.005**
	All Fish	6.54	3	0.088
Month		**Mann-Whitney U**	**Z**	
	All Juvenile Salmon	54.50	-2.64	**0.008**
	Juvenile Chinook	119.00	-0.07	0.984
	Juvenile Chum	82.00	-2.05	0.140
	Juvenile Coho	85.00	-1.46	0.175
	Juvenile Sockeye	61.50	-2.45	**0.019**
	Longfin Smelt	119.00	-0.06	0.984
	All Sticklebacks*	67.50	-2.16	**0.037**
	All Fish	117.50	-0.10	0.922
Station		**Mann-Whitney U**	**Z**	
	All Juvenile Salmon	102.00	-0.69	0.518
	Juvenile Chinook	85.00	-2.32	0.186
	Juvenile Chum	94.50	-1.33	0.336
	Juvenile Coho	87.00	-1.34	0.215
	Juvenile Sockeye	92.00	-1.14	0.297
	Longfin Smelt	98.50	-1.18	0.421
	All Sticklebacks*	115.00	-0.17	0.891
	All Fish	104.50	-0.58	0.570

* Threespine and Ninespine combined

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df = Degrees of Freedom
Z = Critical Value

Table 18 - Invertebrate CPUE by Transect and Station in Tow Net Sampling (May through July 2005)

Species	Transect 1						Transect 2						Transect 3					
	Station						Station						Station					
	1	2	3	4	5	Sum	1	2	3	4	5	Sum	1	2	3	4	5	Sum
Crangon franciscorum	136.7	78.3	86.7	52.7	106.7	92.2	16.8	43.5	82.8	60.0	131.8	64.6	37.3	28.8	62.5	85.3	62.8	55.3
Crangon nigricauda	3.0	1.7	1.3	0.7	0.0	1.3	0.6	1.0	3.3	8.5	5.8	3.7	0.0	0.0	1.8	0.3	0.0	0.4
Crangon spp.	64.7	15.7	8.3	10.3	0.0	19.8	7.8	10.0	7.8	67.3	0.0	18.0	8.8	3.5	5.8	3.5	5.5	5.4
Macoma baltica	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lagunogammarus setosus	36.3	20.7	15.3	29.0	36.7	27.6	16.8	30.5	27.5	33.3	49.5	30.8	35.3	25.8	35.5	22.0	42.5	32.2
Saduria entomon	1.0	0.3	1.0	0.0	0.0	0.5	0.0	0.3	0.8	0.0	0.0	0.2	0.0	0.0	0.3	2.3	0.3	0.6
Mysis litoralis	0.0	0.0	0.0	0.0	0.7	0.1	0.6	2.0	0.0	5.5	0.3	1.6	0.0	0.3	0.3	0.0	0.0	0.1
Neomysis mercedis	0.3	0.3	2.0	9.7	0.0	2.5	13.4	3.3	1.3	1.0	0.0	4.2	8.5	10.8	0.3	2.0	18.5	8.0
Neomysis rayii	14.3	26.0	32.3	64.7	75.0	42.5	27.4	10.5	7.0	39.8	22.5	21.7	35.5	12.8	26.0	17.5	6.5	19.7
Onisimus sp.	77.3	67.0	43.3	46.3	50.7	56.9	30.8	61.0	20.3	25.0	47.3	36.6	48.8	39.0	73.3	43.0	56.5	52.1
Terrestrial insect	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3	0.0	0.3	0.2
Total	333.7	210.0	190.3	213.3	269.7	243.4	114.2	162.0	150.5	240.3	257.0	181.4	174.3	120.8	205.8	175.8	192.8	173.9

Species	Transect 4						Transect 5				Transect 6		
	Station						Station				Station		
	1	2	3	4	5	Sum	1	2	3	Sum	1	2	Sum
Crangon franciscorum	34.3	112.3	103.3	143.7	1.0	82.3	184.5	397.0	51.0	204.3	11.0	0.0	5.5
Crangon nigricauda	0.0	0.0	0.0	0.7	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crangon spp.	12.0	6.8	0.0	3.3	3.7	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Macoma baltica	0.0	0.0	0.3	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lagunogammarus setosus	14.0	15.0	32.8	38.7	13.7	22.9	44.0	77.0	26.0	47.8	12.0	8.0	10.0
Saduria entomon	1.0	0.0	0.0	0.3	0.0	0.2	1.5	198.0	0.0	50.3	0.0	0.0	0.0
Mysis litoralis	0.0	0.0	1.8	1.0	0.0	0.6	0.0	0.0	2.0	0.5	2.0	0.0	1.0
Neomysis mercedis	17.0	0.3	2.5	0.7	0.0	3.8	29.0	19.0	0.0	19.3	0.0	0.0	0.0
Neomysis rayii	21.0	40.0	31.5	25.3	2.0	25.4	14.5	6.0	67.0	25.5	29.0	0.0	14.5
Onisimus sp.	30.3	22.5	61.5	60.7	16.0	38.6	46.5	87.0	40.0	55.0	6.0	3.0	4.5
Terrestrial insect	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.3	0.0	0.0	0.0
Total	129.7	196.8	233.5	274.3	36.3	178.9	320.0	785.0	186.0	402.8	60.0	11.0	35.5

Table 19 - Total Catch and CPUE of Invertebrates in Port MacKenzie Fixed Tow Net

Count	Station			
Species	**PM 00**	**PM 01**	**PM 02**	**Grand Total**
Crangon franciscorum	118	1	133	252
Crangon nigricauda	46	0	21	67
Crangon sp.	72	5	46	123
Lagunogammarus setosus	94	3	269	366
Mysis litoralis	37	0	13	50
Neanthes limnicola	1	0	0	1
Neomysis mercedis	999	0	354	1,353
Neomysis rayii	1,342	0	763	2,105
Onisimus sp.	755	0	625	1,380
Terrestrial insect	1	0	0	1
Mysid unid.	0	0	10	10
Amphipod unid.	0	5	34	39
Grand Total	3465	14	2268	5747

CPUE	Station			
Species	**PM 00**	**PM 01**	**PM 02**	**Grand Total**
Crangon franciscorum	5.90	0.10	4.03	4.00
Crangon nigricauda	2.30	0.00	0.64	1.06
Crangon sp.	3.60	0.50	1.39	1.95
Lagunogammarus setosus	4.70	0.30	8.15	5.81
Mysis litoralis	1.85	0.00	0.39	0.79
Neanthes limnicola	0.05	0.00	0.00	0.02
Neomysis mercedis	49.95	0.00	10.73	21.48
Neomysis rayii	67.10	0.00	23.12	33.41
Onisimus sp.	37.75	0.00	18.94	21.90
Terrestrial insect	0.05	0.00	0.00	0.02
Mysid unid.	0.00	0.00	0.30	0.16
Amphipod unid.	0.00	0.50	1.03	0.62
Grand Total	**173.25**	**1.40**	**68.73**	**91.22**

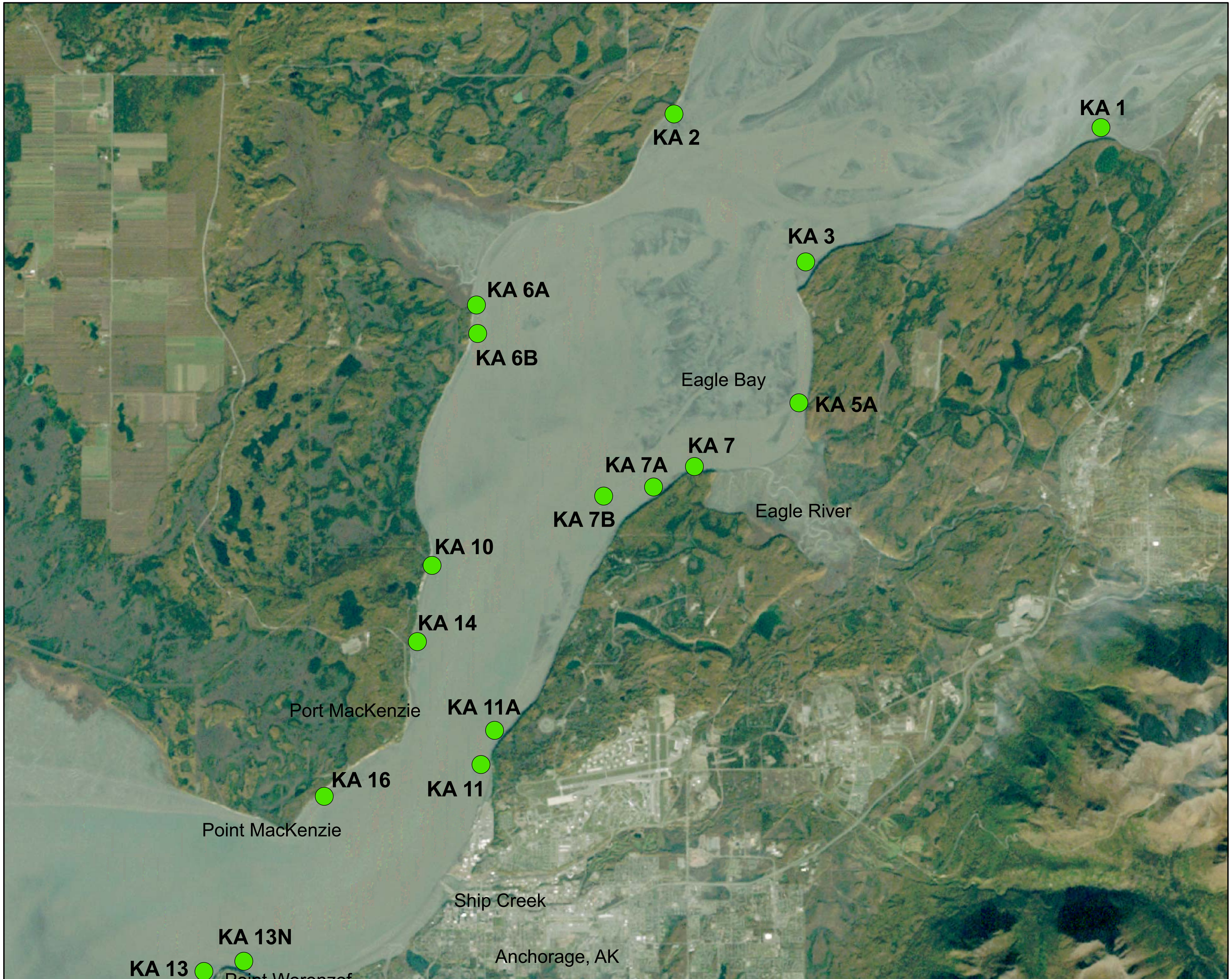
Table 20 - Total Catch and CPUE of Invertebrates in Port MacKenzie 30-Foot Beach Seine

Count	Station								
Species	**PM N1**	**PM N2**	**PM N3**	**PM S1**	**PM S2**	**PM S3**	**PM S4**	**PM SS**	**Grand Total**
Amphipod unid.	3	0	0	4	0	0	0	1	8
Crangon franciscorum	2	0	3	3	0	3	2	0	13
Crangon nigricauda	4	1	2	4	1	2	0	0	14
Crangon sp.	18	2	3	18	2	4	2	4	53
Lagunogammarus setosus	2	0	1	2	1	1	1	0	8
Saduria entomon	0	0	0	1	0	0	0	0	1
Mysid unid.	3	0	0	6	0	0	0	0	9
Neomysis mercedis	0	0	0	2	0	0	0	0	2
Neomysis rayii	3	1	3	2	1	3	2	0	15
Onisimus sp.	0	1	3	4	1	3	2	0	14
Grand Total	**35**	**5**	**15**	**46**	**6**	**16**	**9**	**5**	**137**
# Reps	**18**	**5**	**7**	**18**	**2**	**7**	**2**	**1**	**60**

CPUE	Station								
Species	**PM N1**	**PM N2**	**PM N3**	**PM S1**	**PM S2**	**PM S3**	**PM S4**	**PM SS**	**Grand Total**
Amphipod unid.	0.2	0.0	0.0	0.2	0.0	0.0	0.0	1.0	0.1
Crangon franciscorum	0.1	0.0	0.4	0.2	0.0	0.4	1.0	0.0	0.2
Crangon nigricauda	0.2	0.2	0.3	0.2	0.5	0.3	0.0	0.0	0.2
Crangon sp.	1.0	0.4	0.4	1.0	1.0	0.6	1.0	4.0	0.9
Lagunogammarus setosus	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Mysid unid.	0.2	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.2
Neomysis mercedis	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Neomysis rayii	0.2	0.2	0.4	0.1	0.5	0.4	1.0	0.0	0.3
Onisimus sp.	0.0	0.2	0.4	0.2	0.5	0.4	1.0	0.0	0.2
Grand Total	**1.9**	**1.0**	**2.1**	**2.6**	**3.0**	**2.3**	**4.5**	**5.0**	**2.3**

FIGURES

Knik Arm Crossing Beach Seine Stations Figure 1



Legend

KA 1 ● Beach Seine Station and Number

Map Notes:

Map Projection:
AK State Plane Zone 4, NAD 83

File: R:/00214 HDR/012 KABATA/figures/GIS/BeachSeineLocations.MXD or PDF

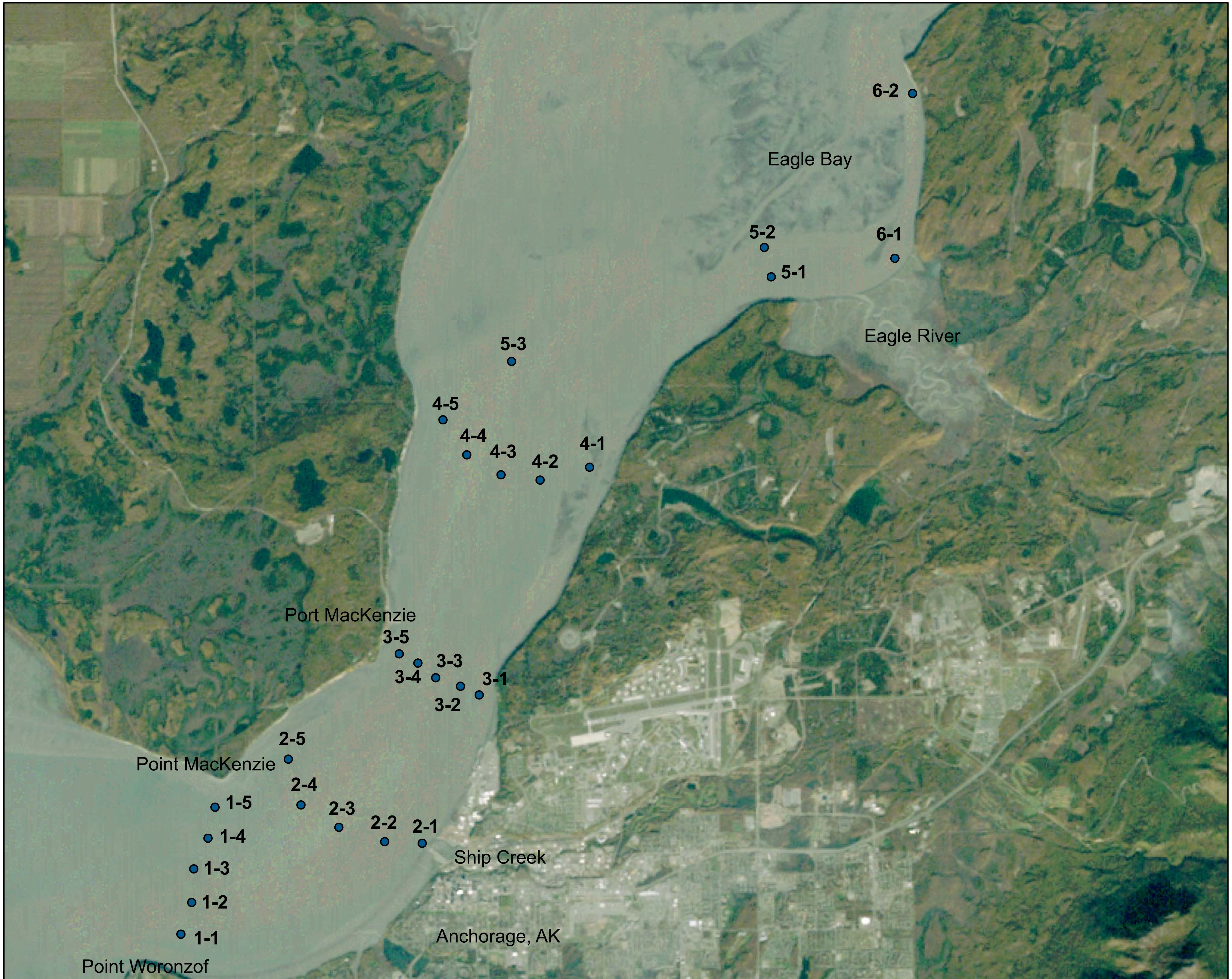
Data Sources: Mat-Su Borough, Municipality of Anchorage

Author: Pentec Environmental
December 2005

0 1 2 Miles

N S W E

Knik Arm Crossing
Tow Net Locations
Figure 2



Legend

1-3 ● Tow Net Location and Number (Transect - Station)

Map Notes:

Map Projection:
AK State Plane Zone 4, NAD 83

File: R:/00214 HDR/012 KABATA/figures/GIS/TowNetLocations.MXD or PDF

Data Sources: Mat-Su Borough, Municipality of Anchorage

Author: Pentec Environmental
December 2005

0 0.75 1.5 Miles

N W E S

Knik Arm Crossing
Port MacKenzie
Sampling Locations
Figure 3

Legend

PM N4 — 30-foot Beach Seine Station and Number

PM 00 — Fixed Tow Net Station and Number

Note: Aerial Photo taken during Costruction of Port MacKenzie pier. Current configuration has an additional T-section on the offshore end of the pier.

Map Notes:

Map Projection:
AK State Plane Zone 4, NAD 83

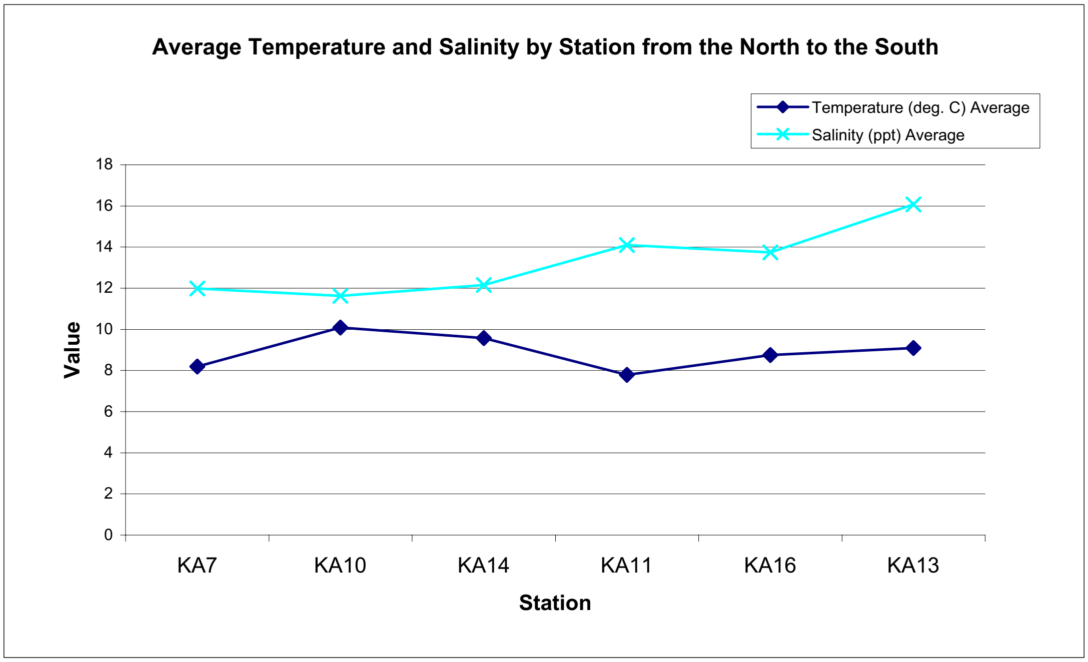
File: R:/00214 HDR/012 KABATA/figures/GIS/PortMacKenzieLocations.MXD or PDF

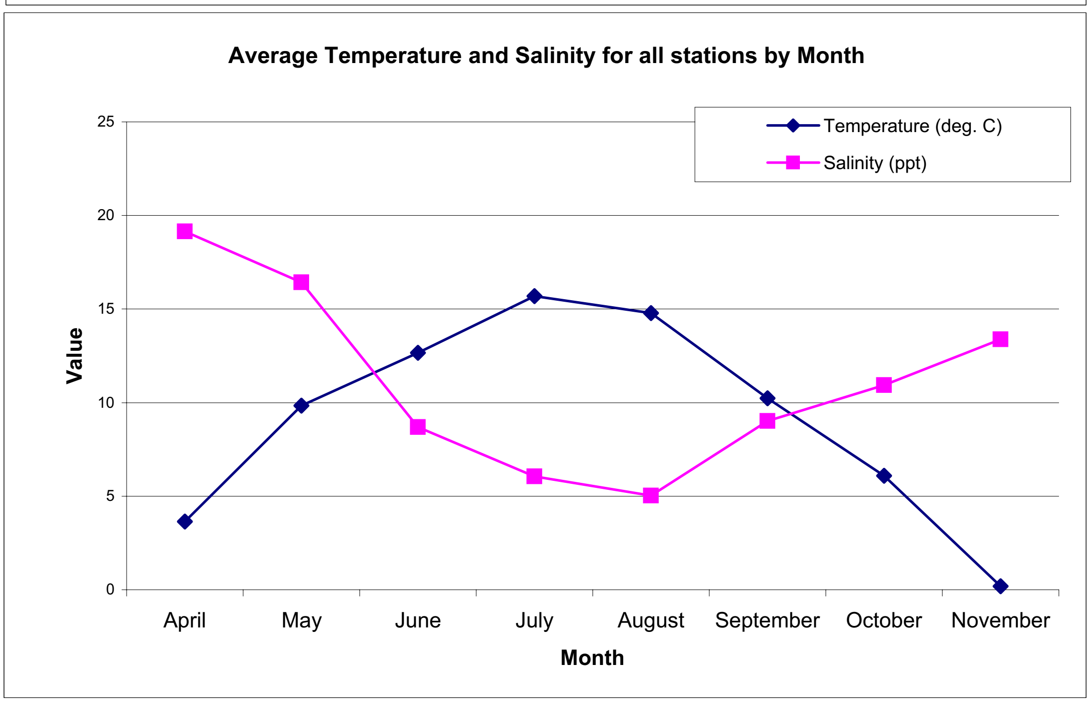
Data Sources: Mat-Su Borough, Municipality of Anchorage

Author: Pentec Environmental
December 2005

0 0.05 0.1 Miles

Water Quality of Knik Arm, 2004 - 2005





00214\012\Final Report 11-30-2005\Fig 4

Notes: April through June data are from 2004;
July through November data are from 2005.

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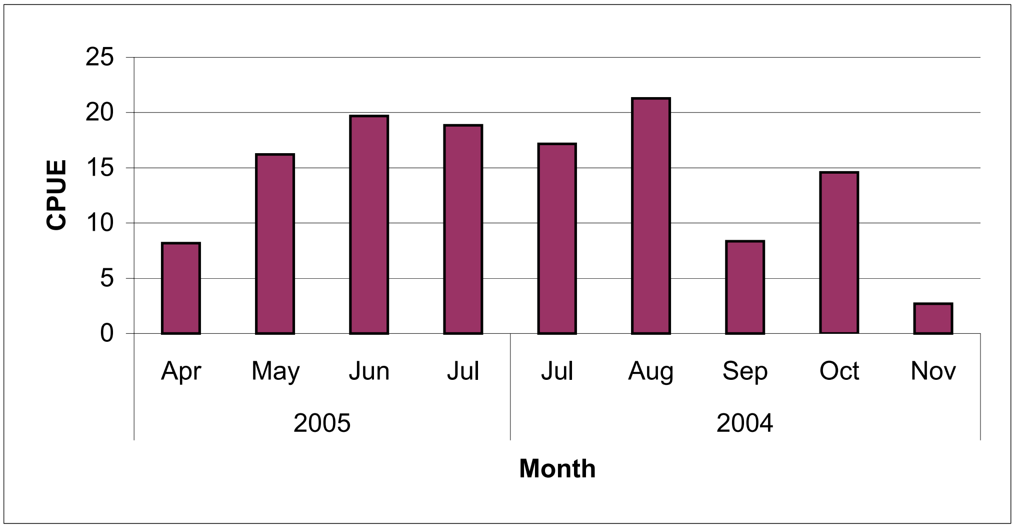
Figure 4

CPUE over Time for all Fish Species 120-Foot Beach Seine



00214\012\Final Report 11-30-2005\Fig 5

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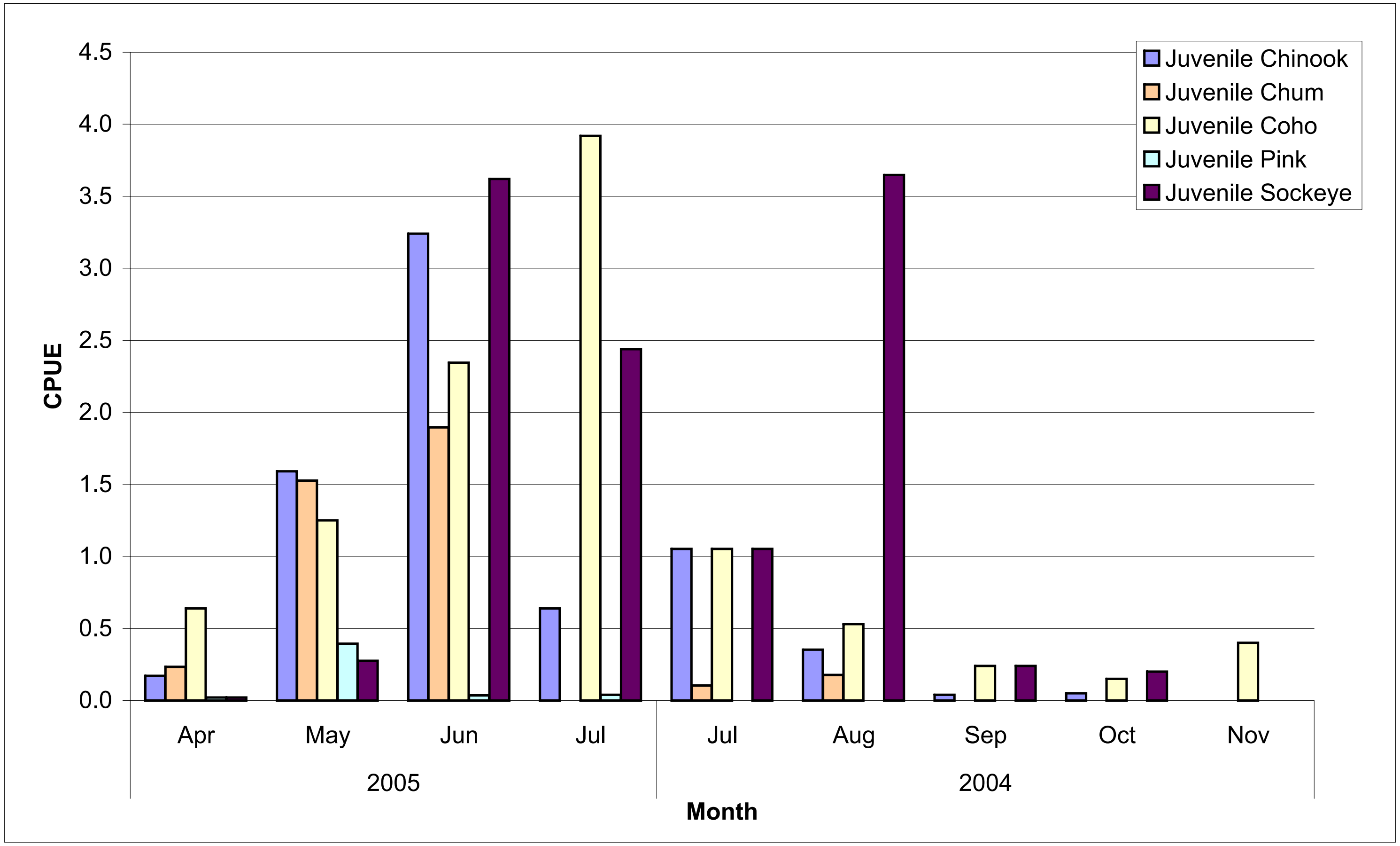
Figure 5

Juvenile Salmonid CPUE over Time; 120-Foot Beach Seine



00214\012\Final Report 11-30-2005\Fig 6

PENTEC ENVIRONMENTAL
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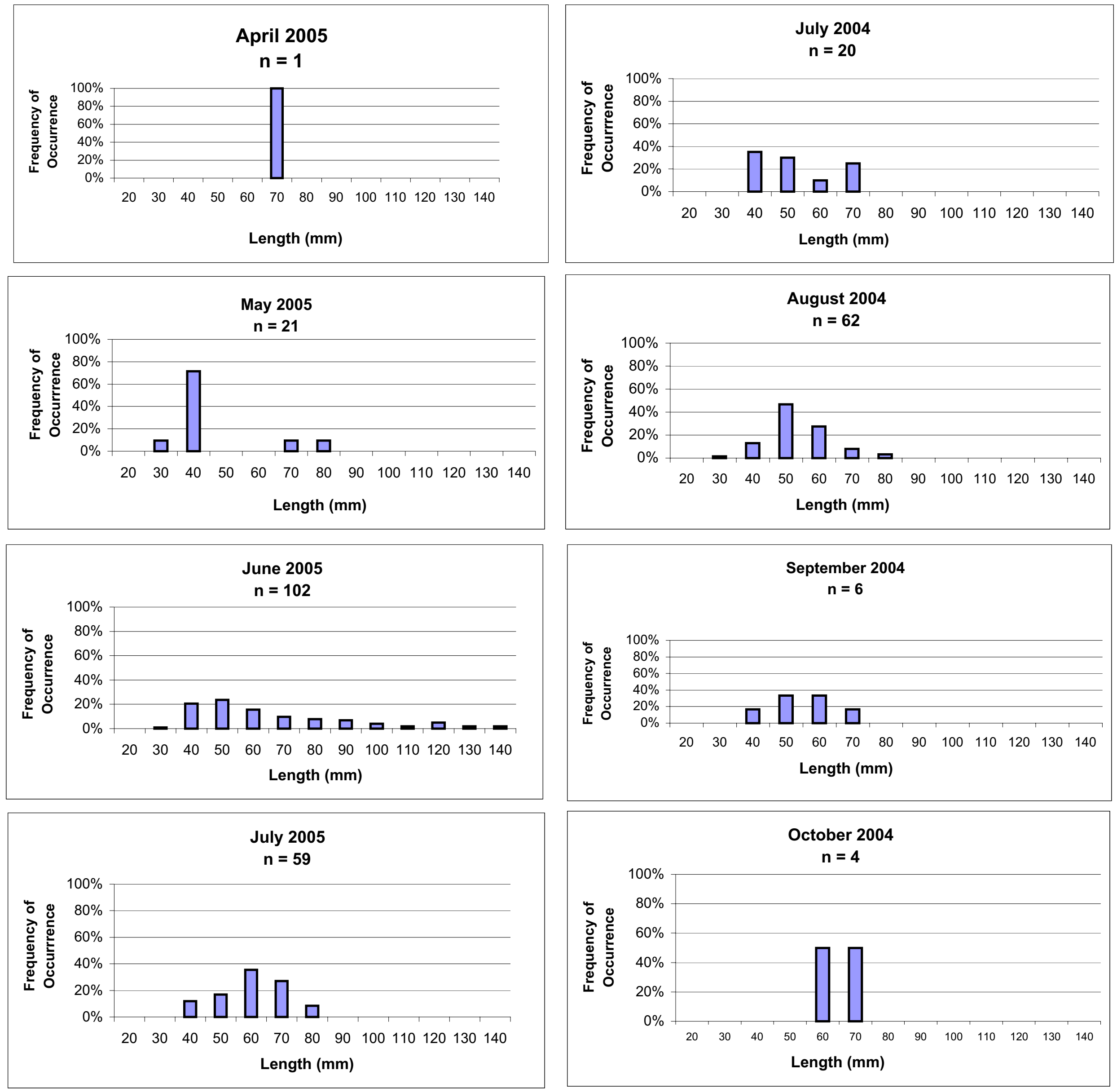
11/05

Length Frequencies of Juvenile Sockeye Salmon over Time; 120-Foot Beach Seine



00214\012\Final Report 11-30-2005\Fig 7

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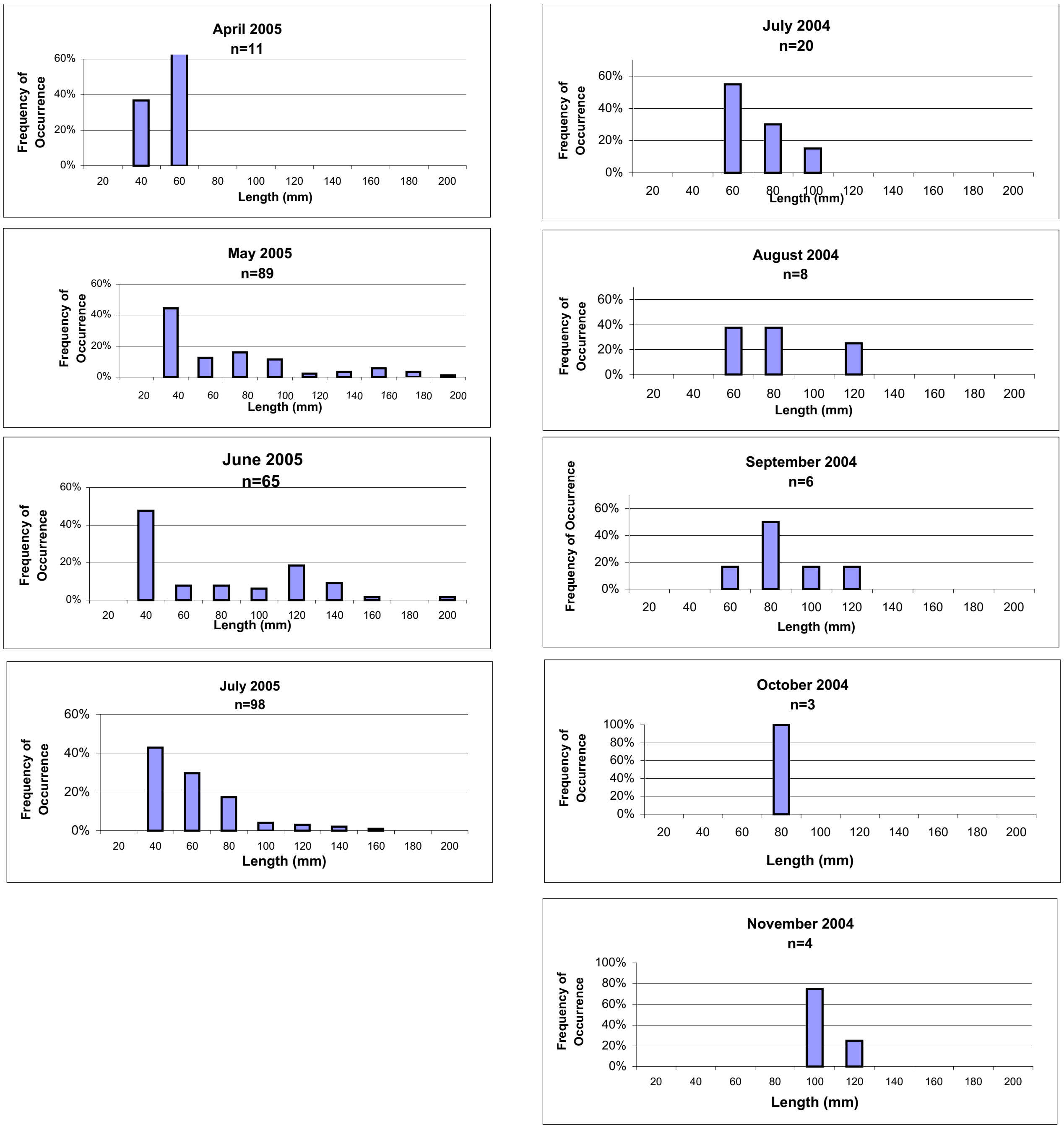
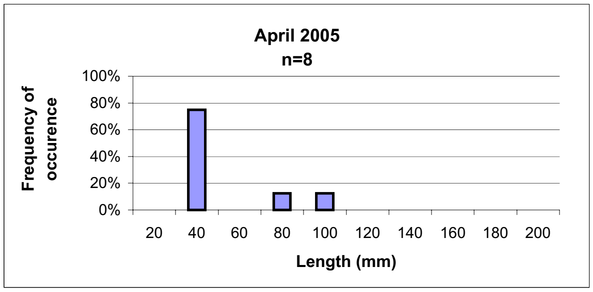
Figure 7

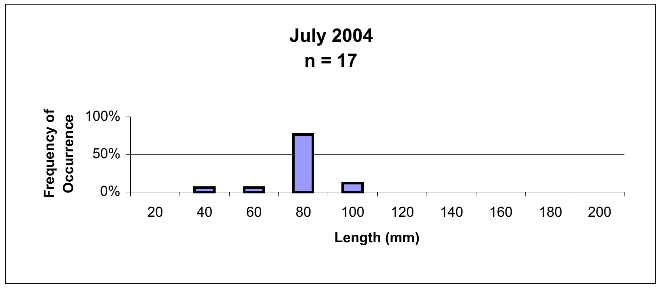
Length Frequencies of Juvenile Coho Salmon over Time; 120-Foot Beach Seine

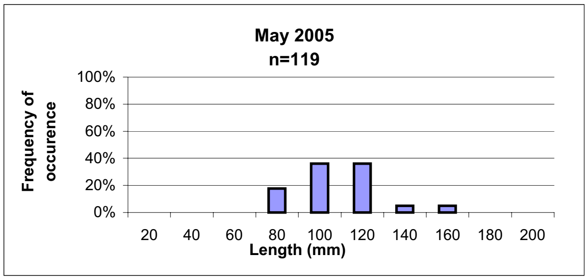


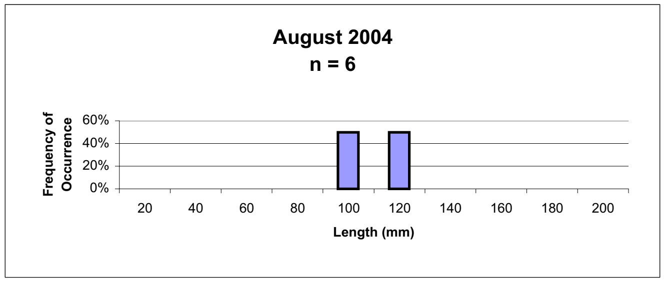
00214\012\Final Report 11-30-2005\Fig 8

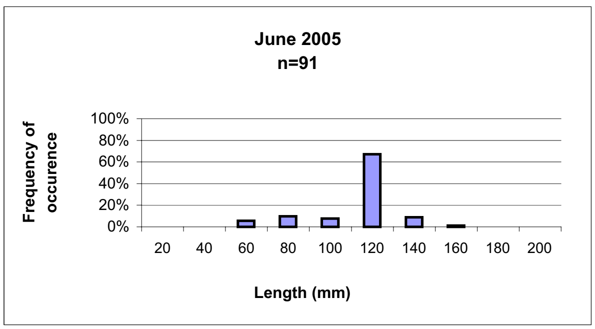
Length Frequencies of Juvenile Chinook Salmon over Time; 120-Foot Beach Seine

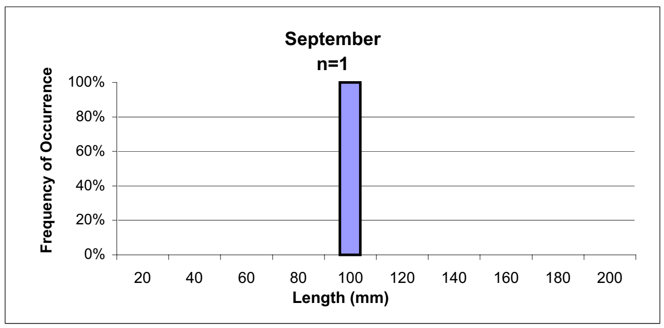


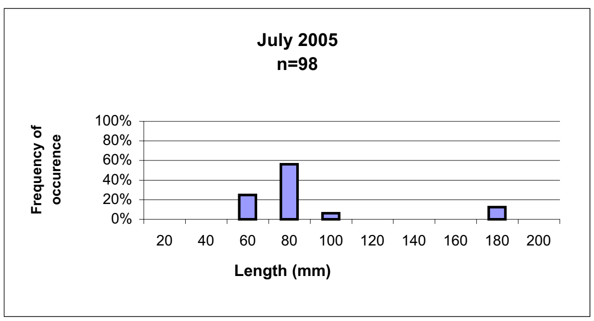


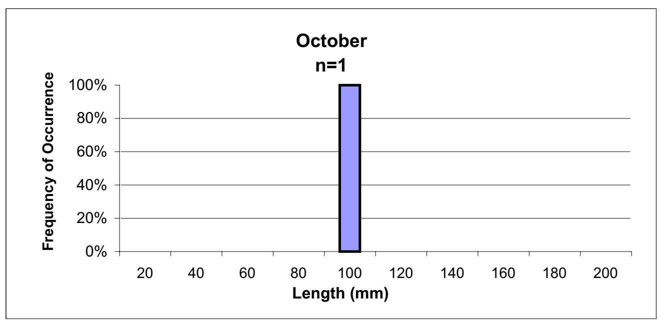






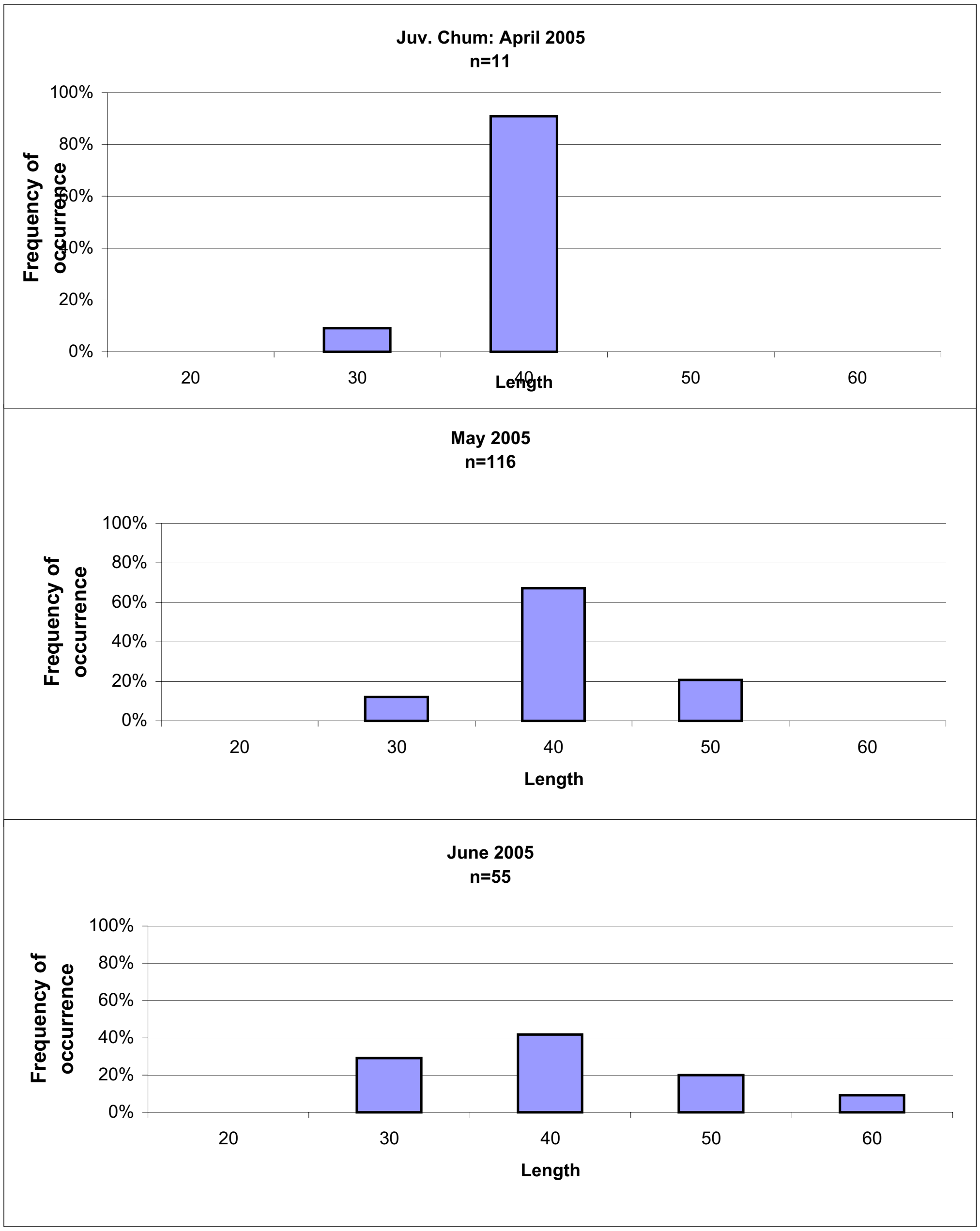






00214\012\Final Report 11-30-2005\Fig 9

Length Frequencies of Juvenile Chum Salmon over Time; 120-Foot Beach Seine



00214\012\Final Report 11-30-2005\Fig 10

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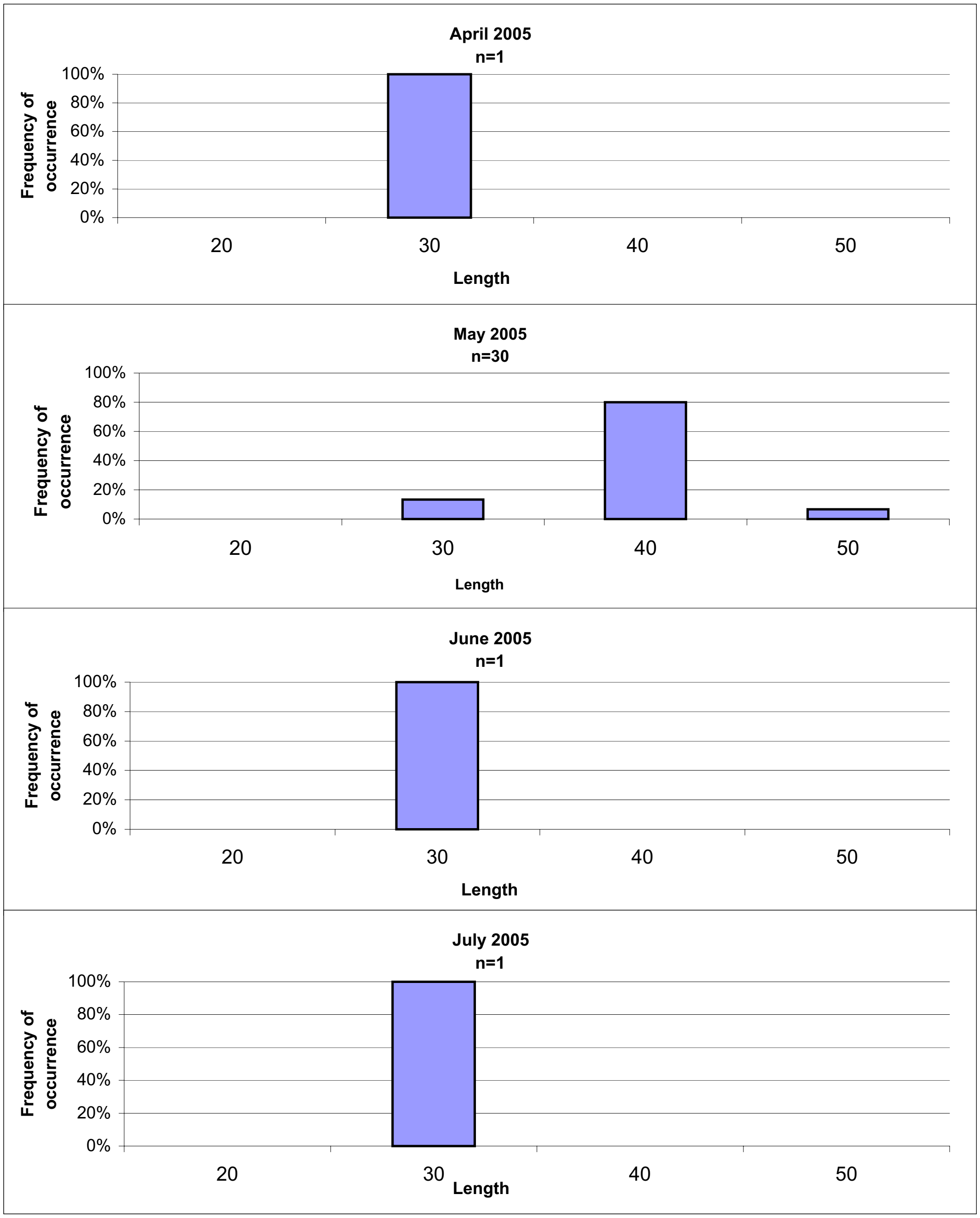
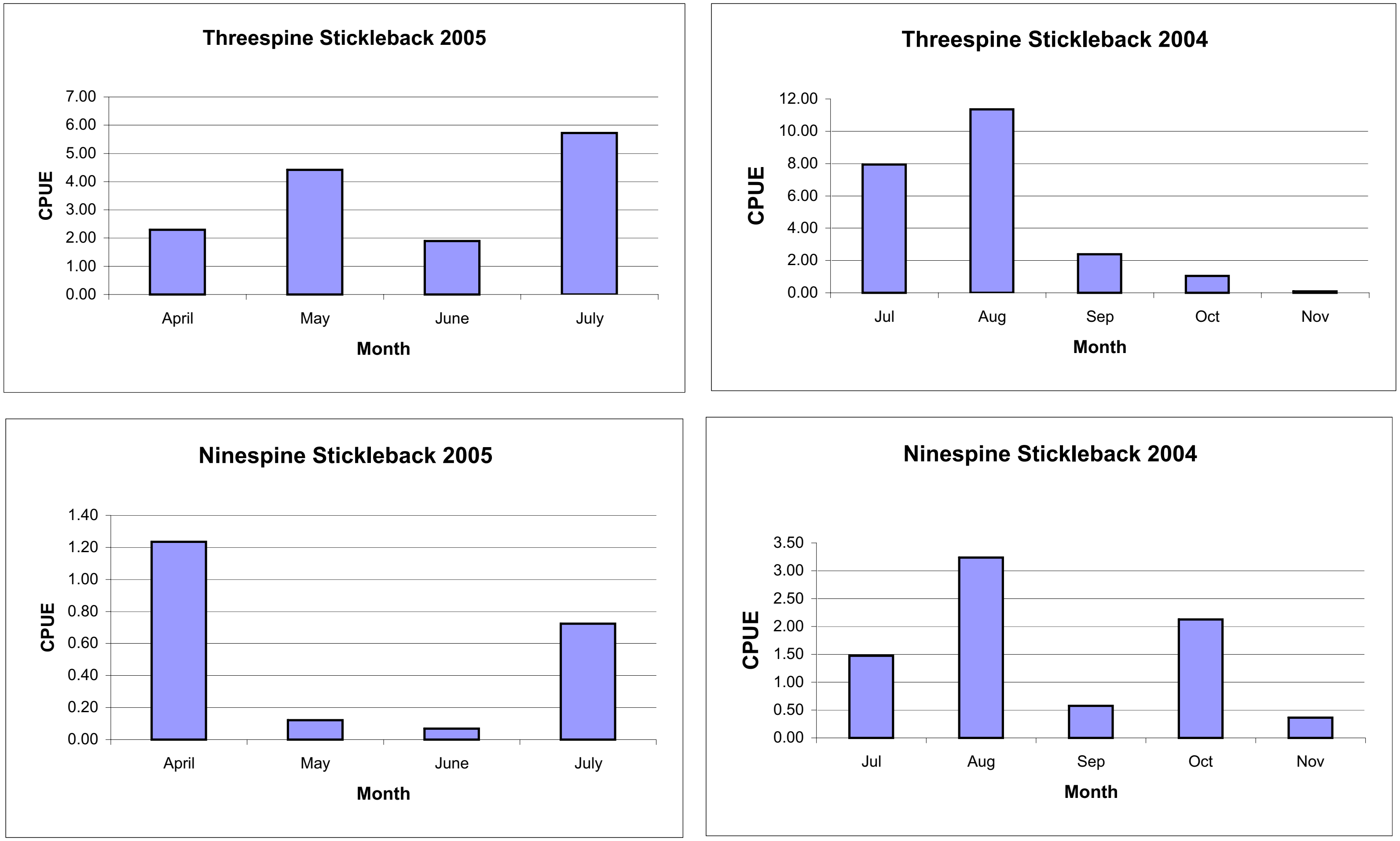
Figure 10

Length Frequencies of Juvenile Pink Salmon over Time; 120-Foot Beach Seine



00214\012\Final Report 11-30-2005\Fig 11

CPUE for Stickleback Species; 120-Foot Beach Seine



00214012\Final Report 11-30-2005\Fig 12

PENTEC ENVIRONMENTAL
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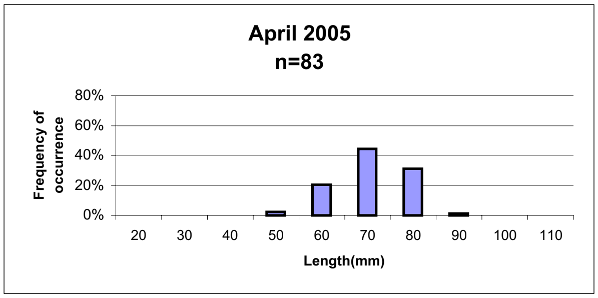
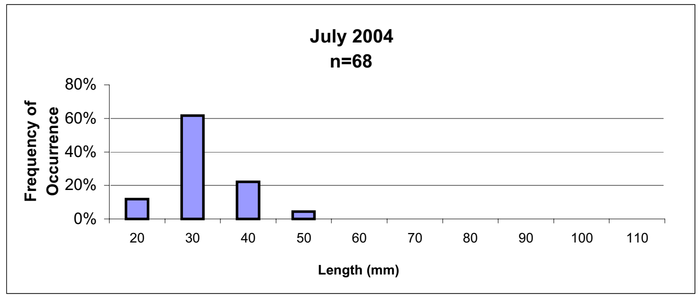
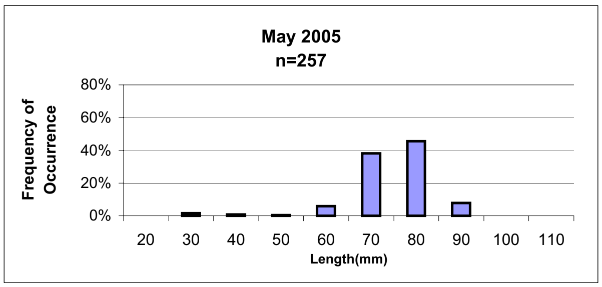
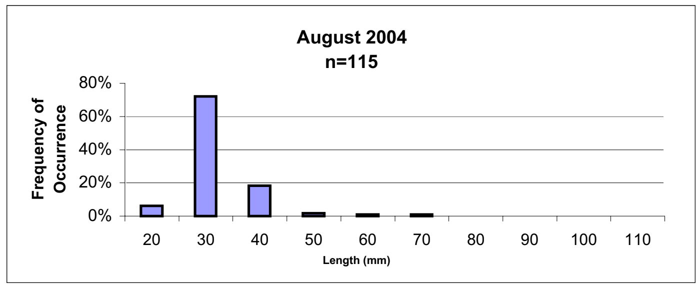
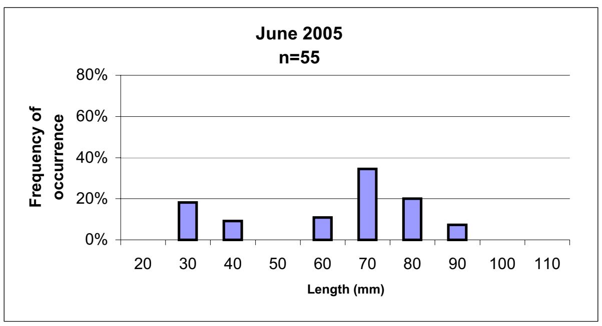
Length Frequencies of Threespine Stickleback over Time; 120-Foot Beach Seine

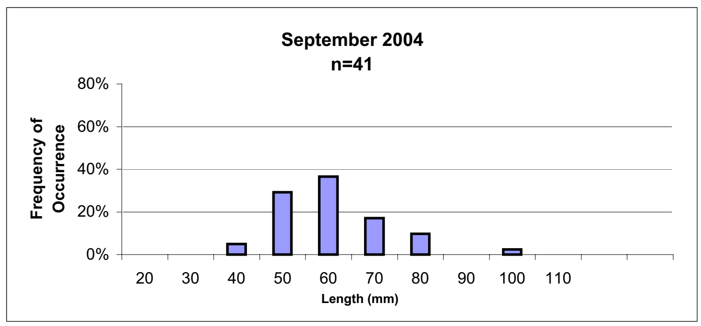


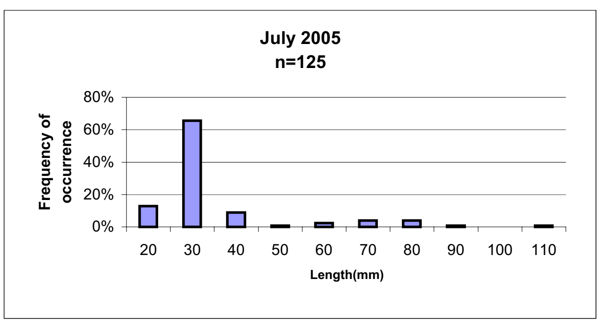


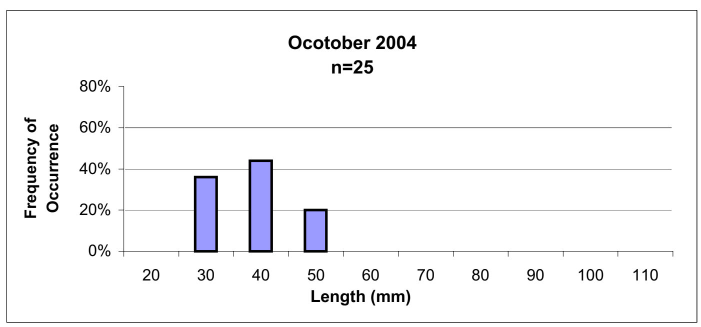


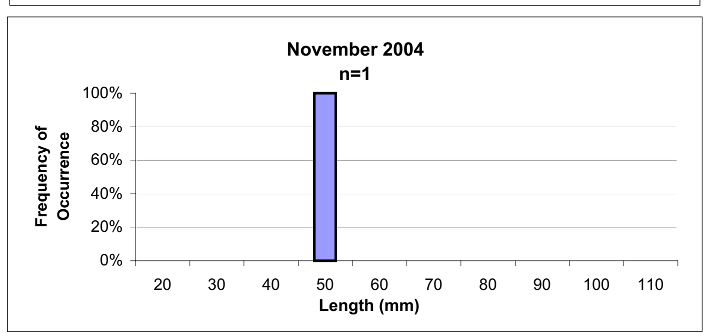




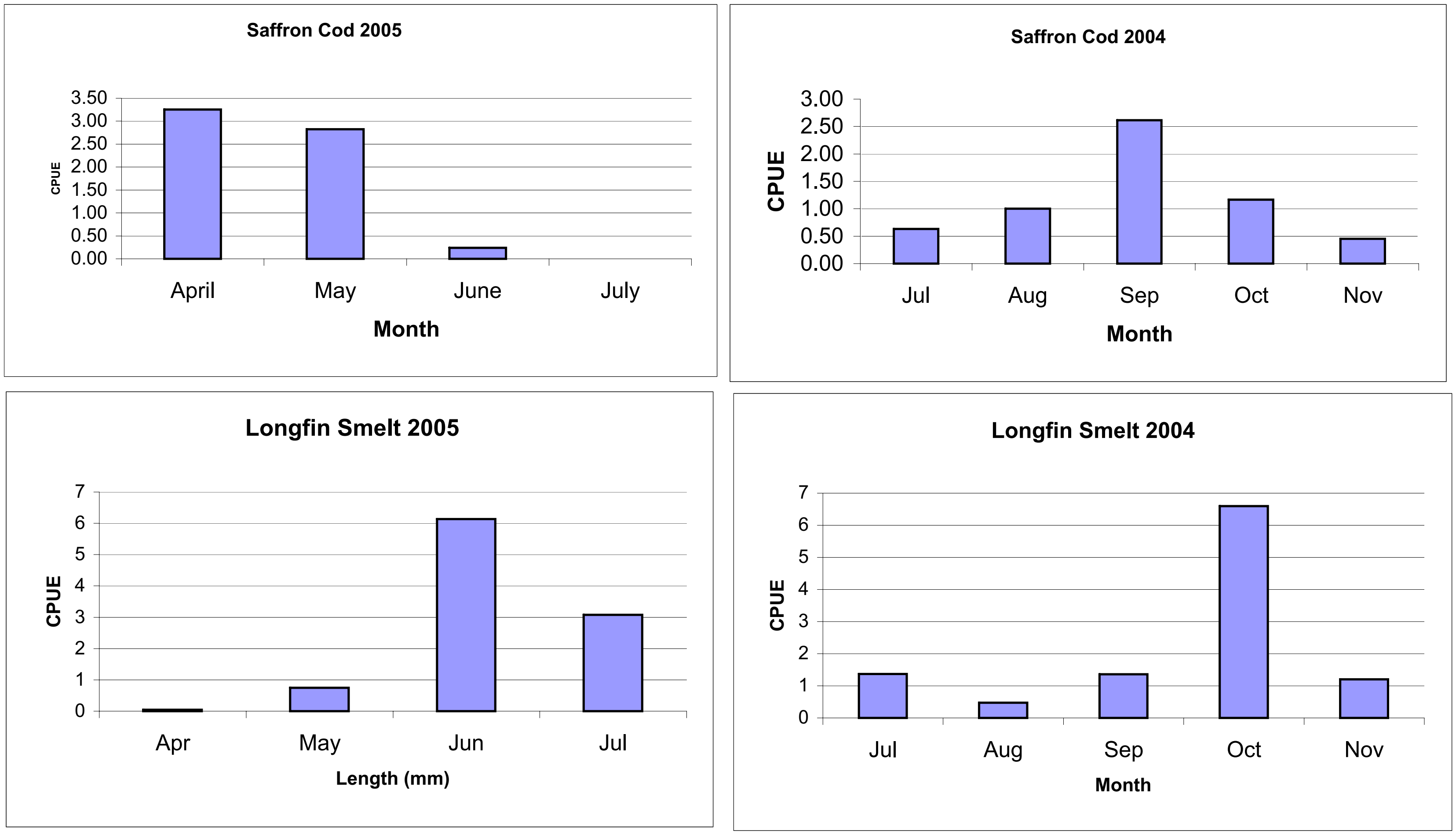








CPUE for Saffron Cod and Longfin Smelt in 120-Foot Beach Seine



00214012\Final Report 11-30\2005\KABATA Report Figure 2\Fig 14

PENTEC ENVIRONMENTAL

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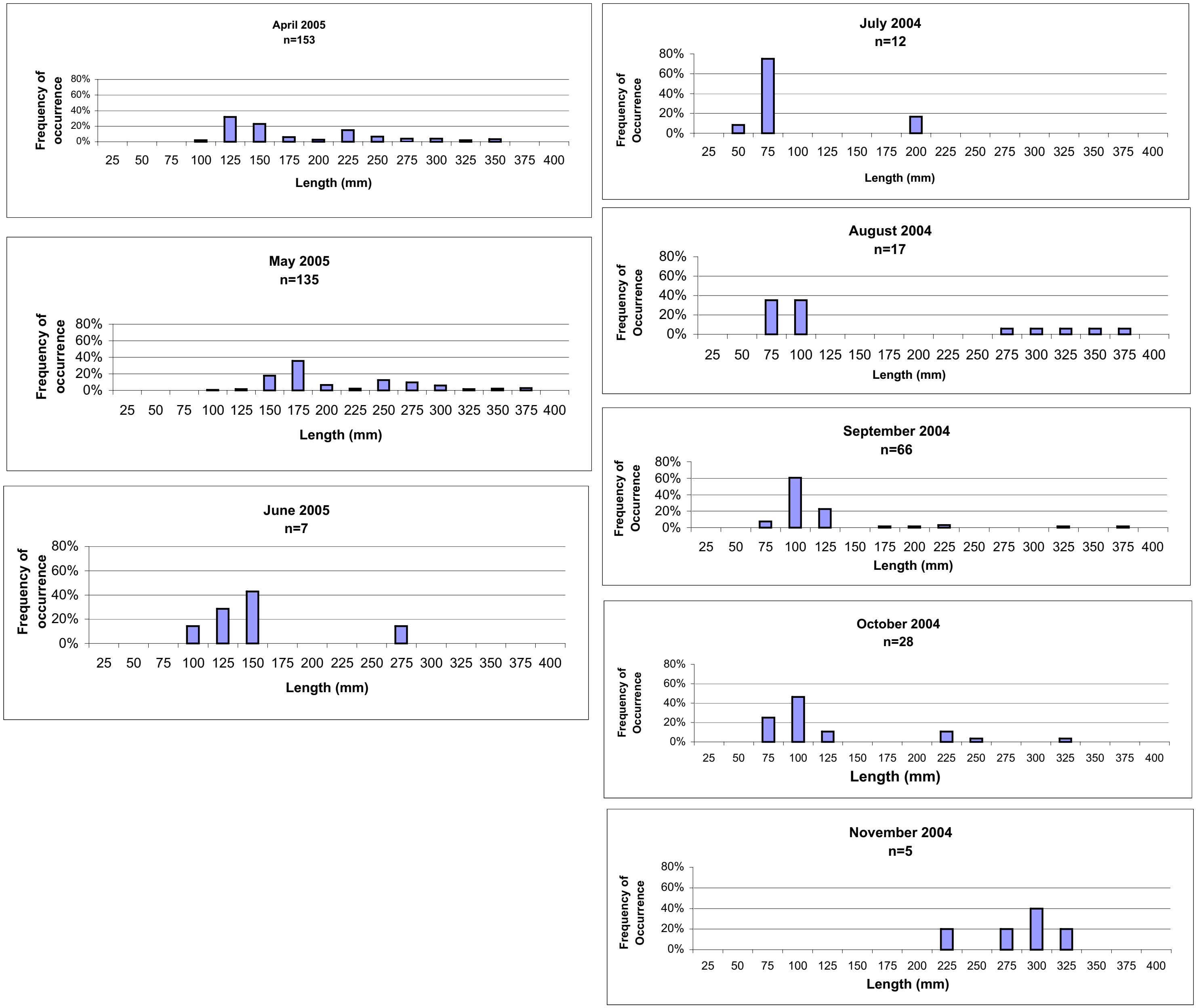
11/05

Length Frequencies of Saffron Cod over Time; 120-Foot Beach Seine



PENTEC ENVIRONMENTAL
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Figure 15
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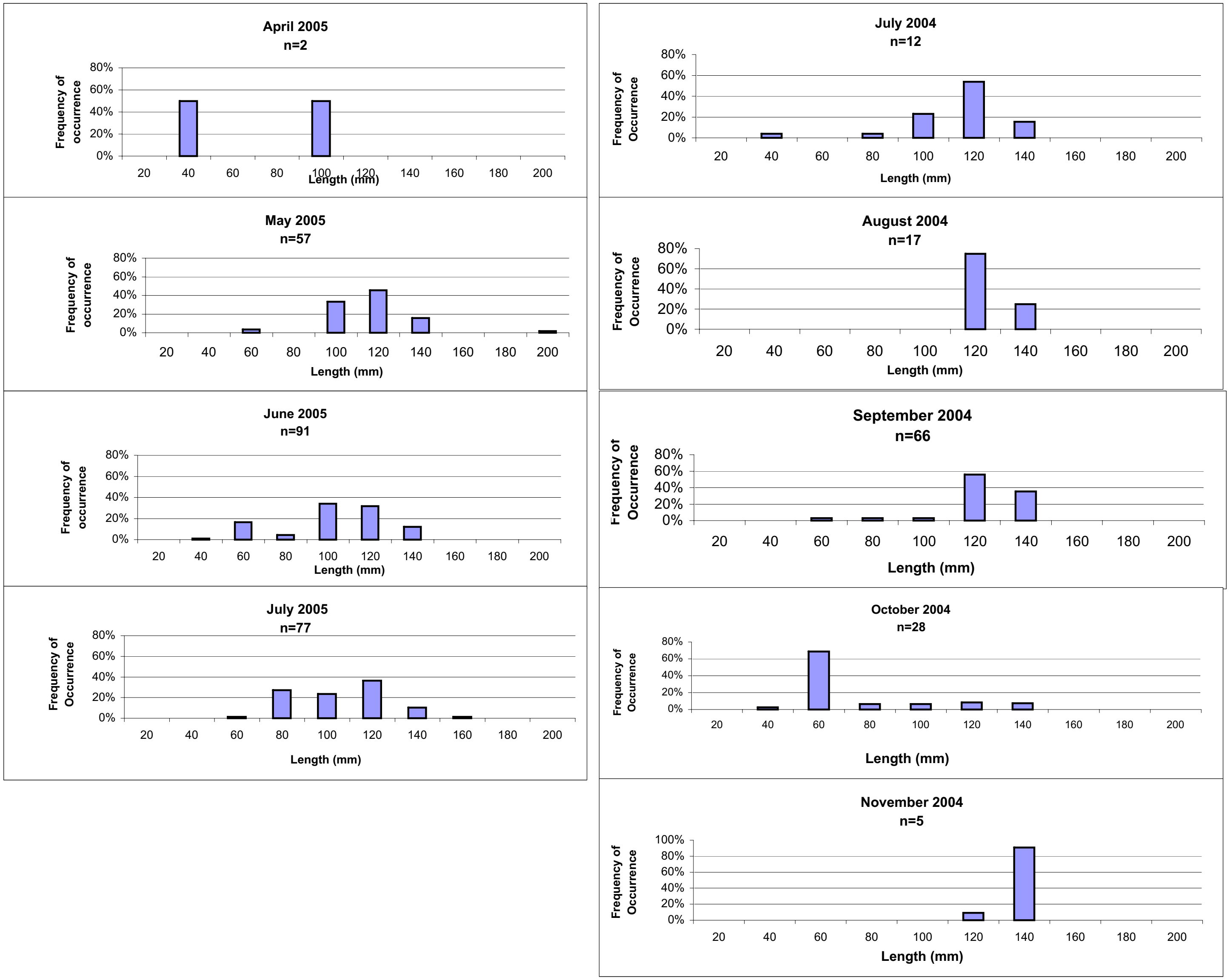
00214012\Final Report 11-30-2005\Fig 15

Length Frequencies of Longfin Smelt over Time; 120-Foot Beach Seine



00214\012\Final Report 11-30-2005\Fig 16

PENTEC ENVIRONMENTAL
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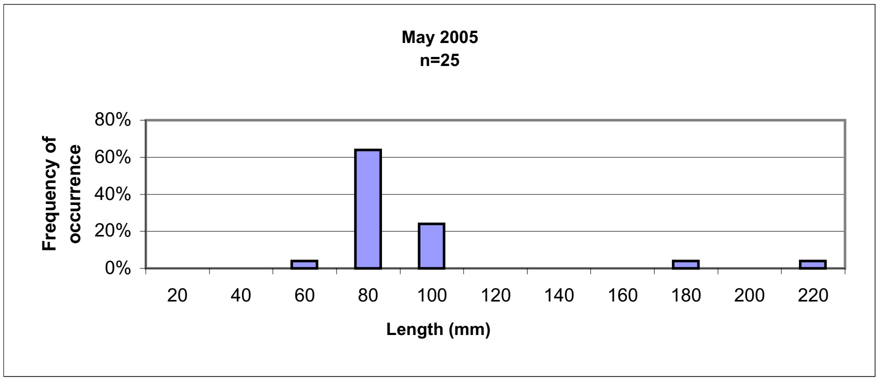
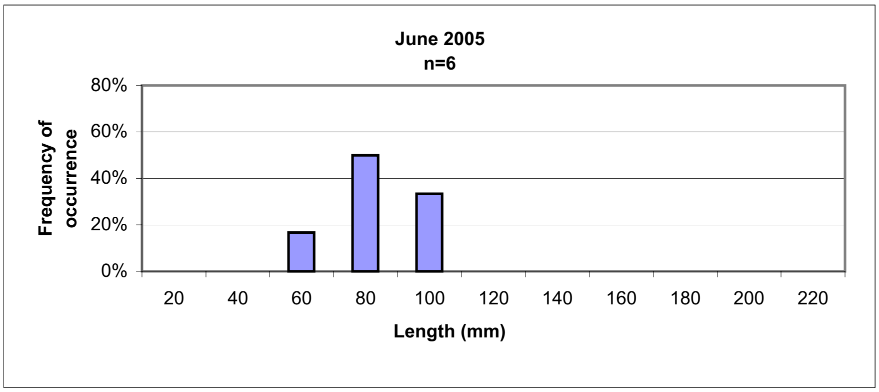
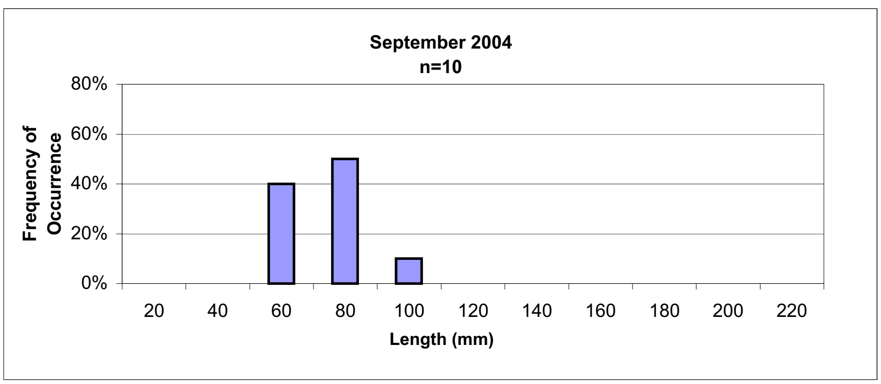
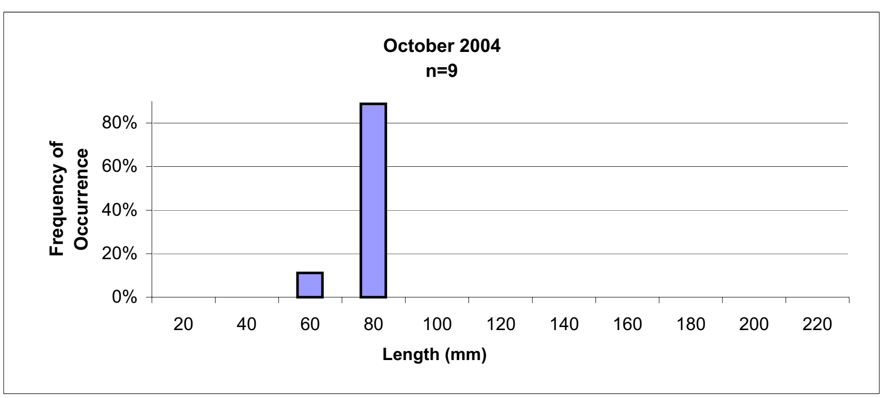
Figure 16
11/05

Length Frequencies of Pacific Herring over Time



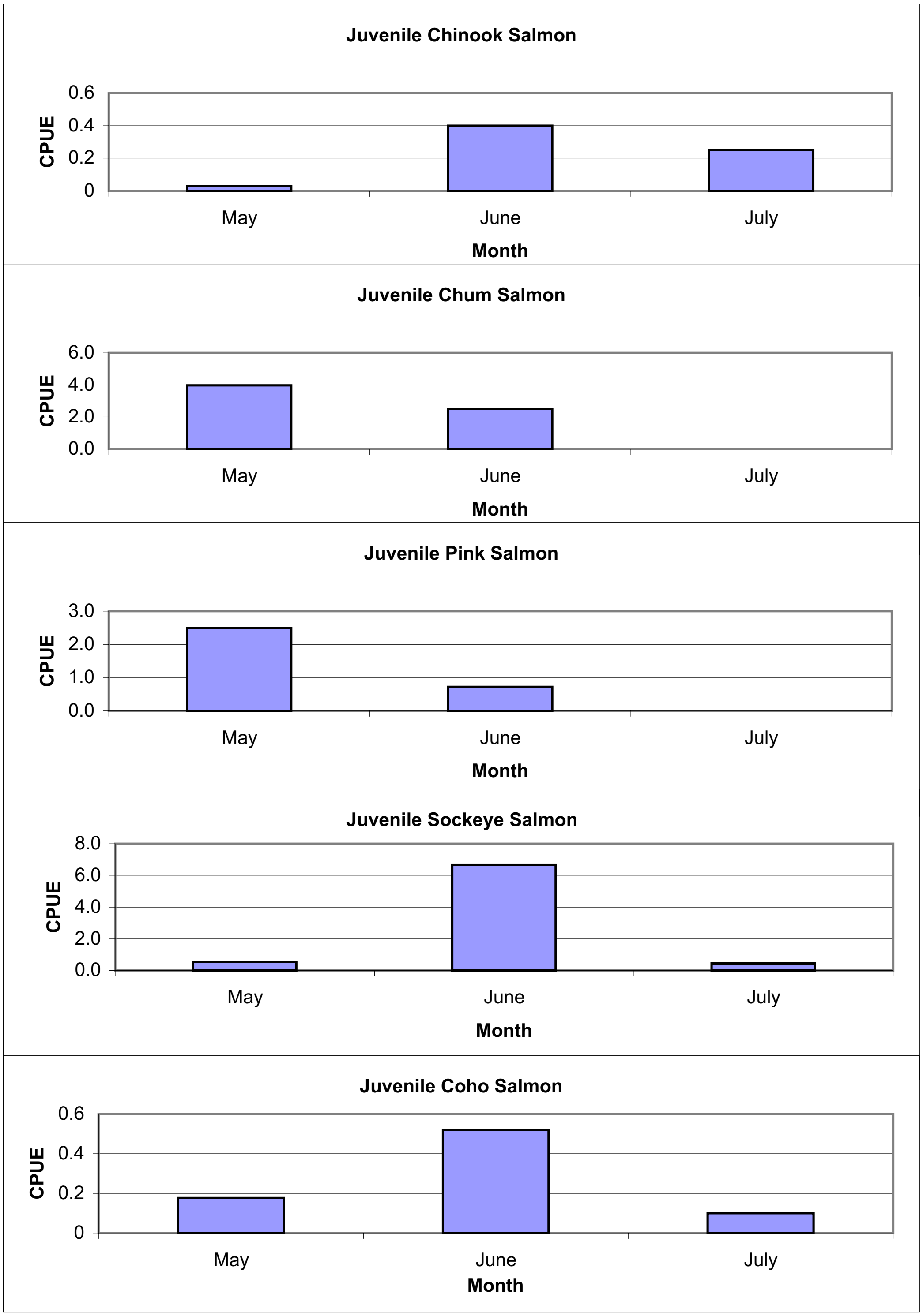






00214\012\Final Report 11-30-2005\Fig 17

Juvenile Salmonid CPUE over Time in Tow Net



00214\012\Final Report 11-30-2005\Fig 18

PENTEC ENVIRONMENTAL

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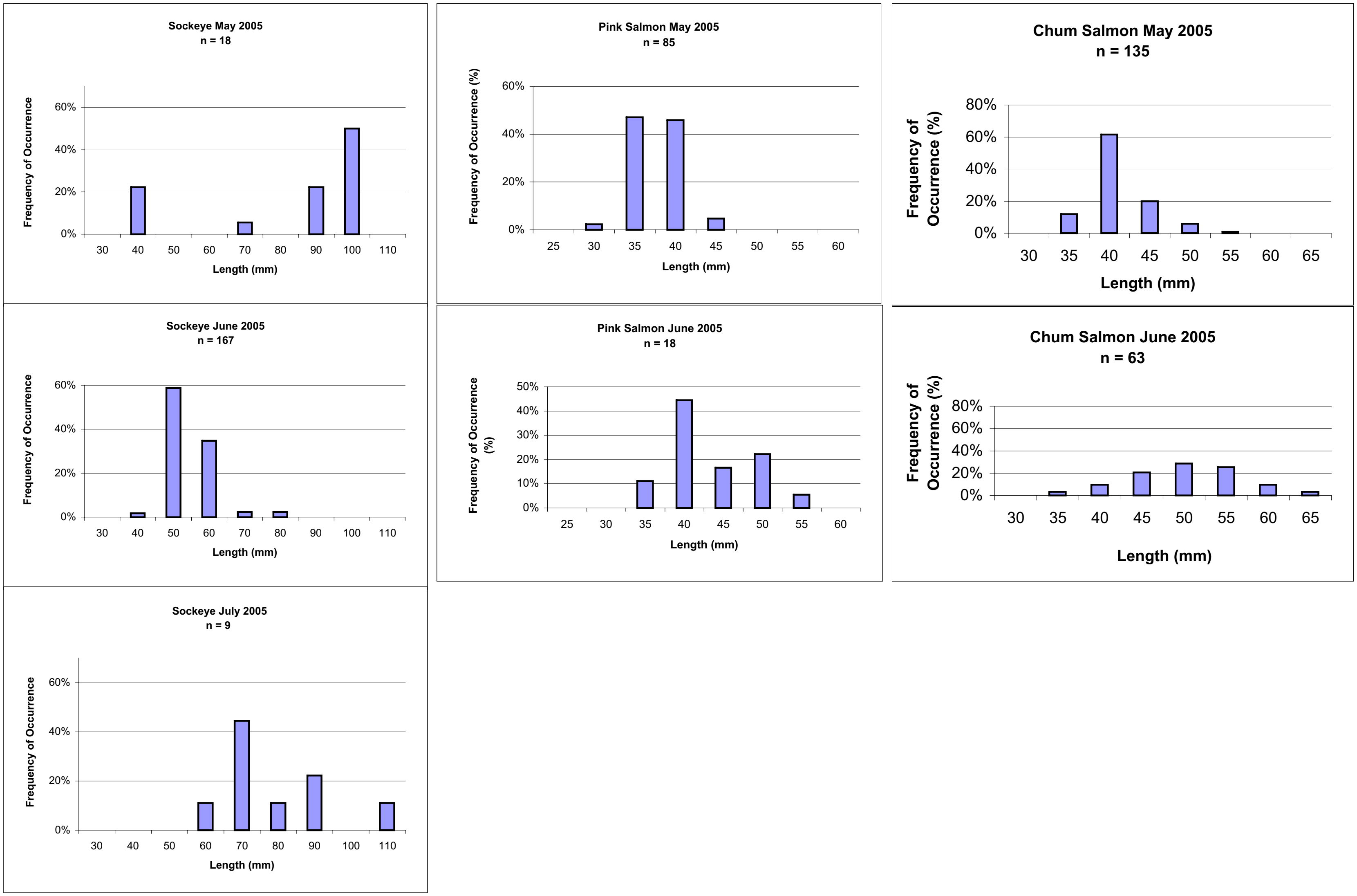
Figure 18

Length Frequencies of Sockeye, Pink, and Chum Salmon over Time in Tow Net



PENTEC ENVIRONMENTAL
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Figure 19
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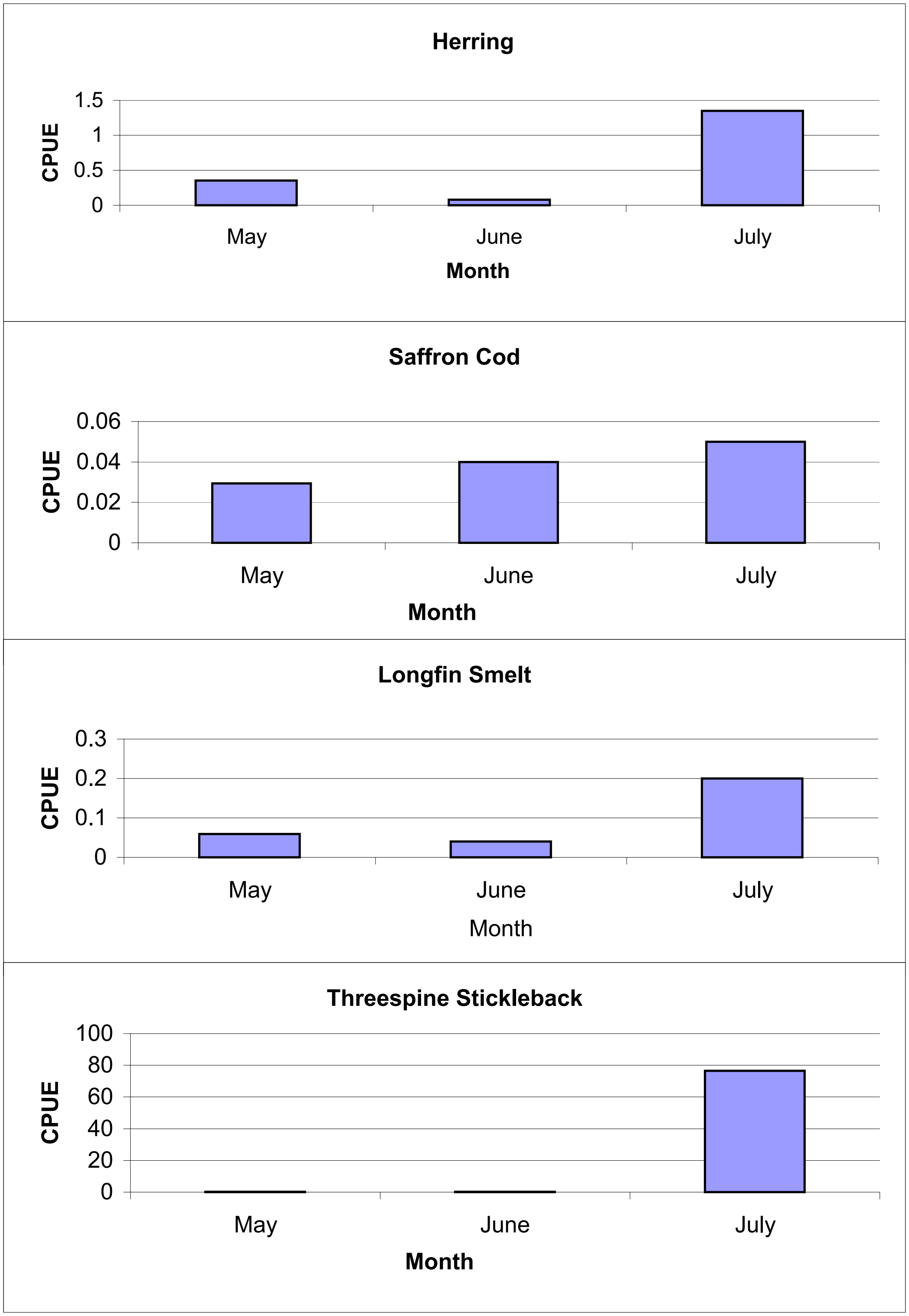
00214\012\Final Report 11-30-2005\Fig 19

Non-Salmonid CPUE over Time in Tow Net



00214\012\Final Report 11-30-2005\Fig 20

PENTEC ENVIRONMENTAL

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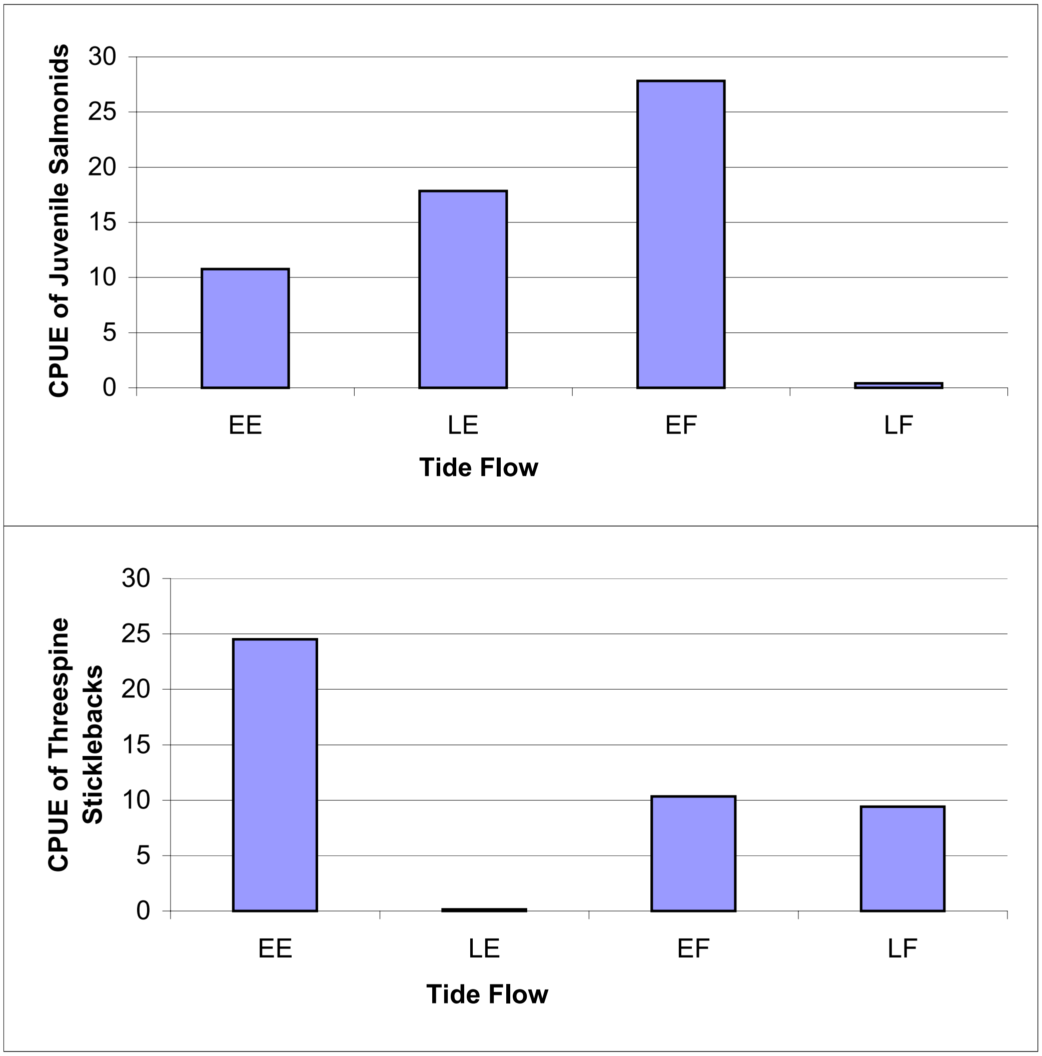
Figure 20

CPUE of Salmonids and Threespine Stickleback as a Function of Tide; Fixed Tow Net



00214\012\Final Report 11-30-2005\Fig 21

Notes: EE = Early Ebb
LE = Late Ebb
EF = Early Flood
LF = Late Flood

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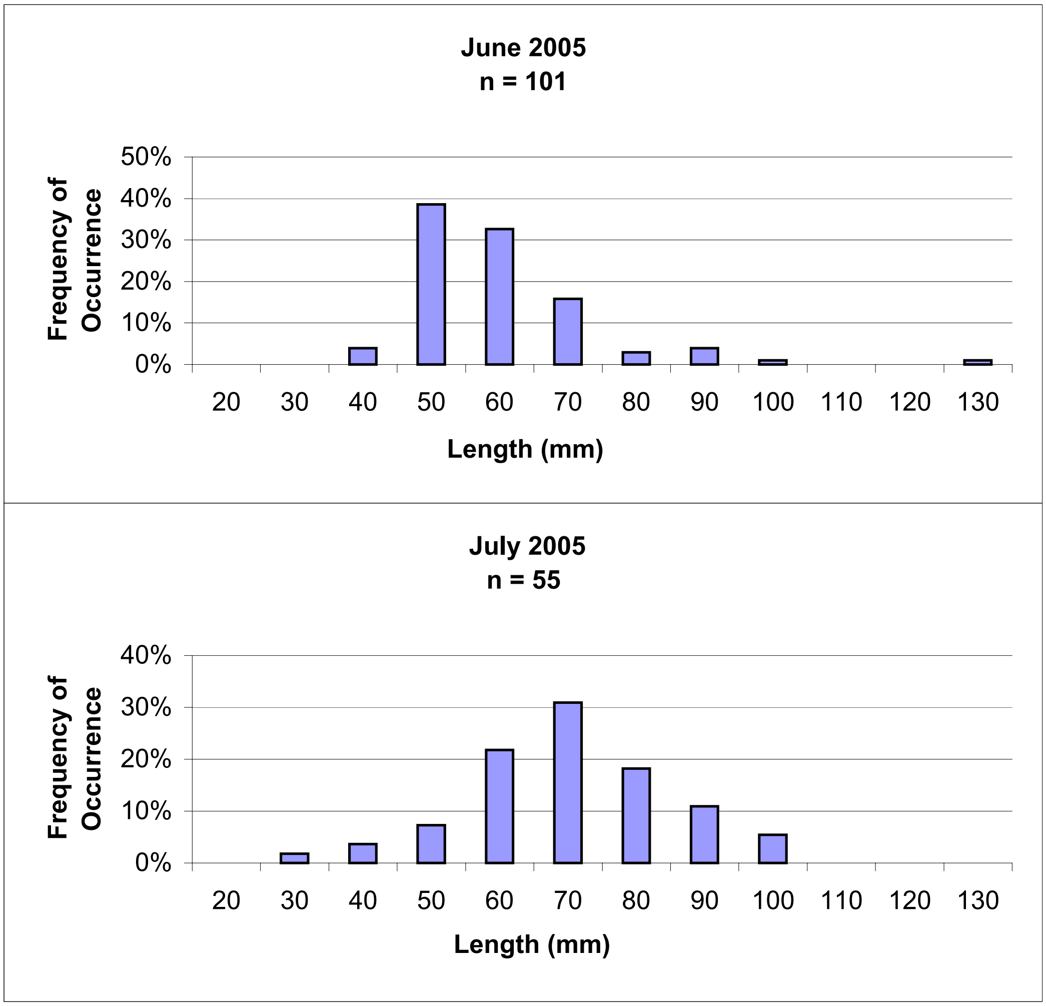
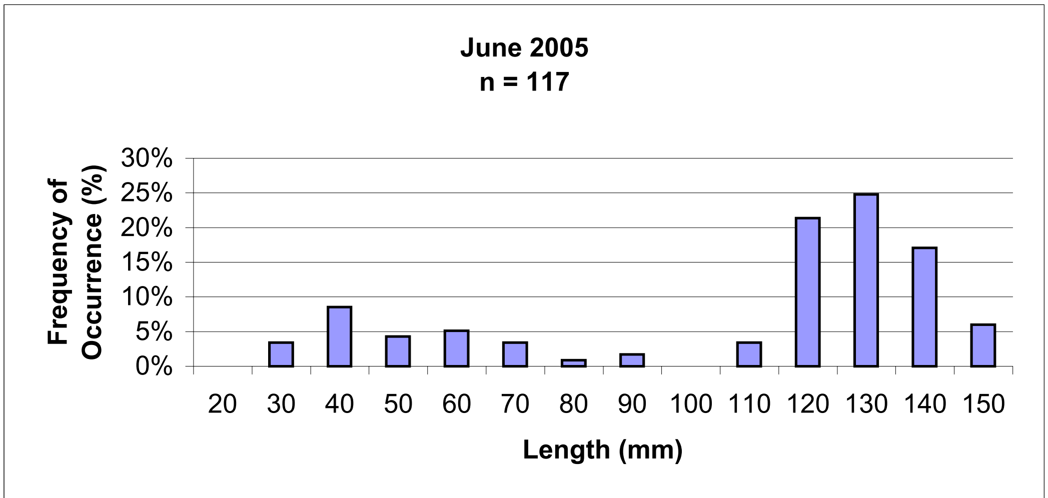
Figure 21

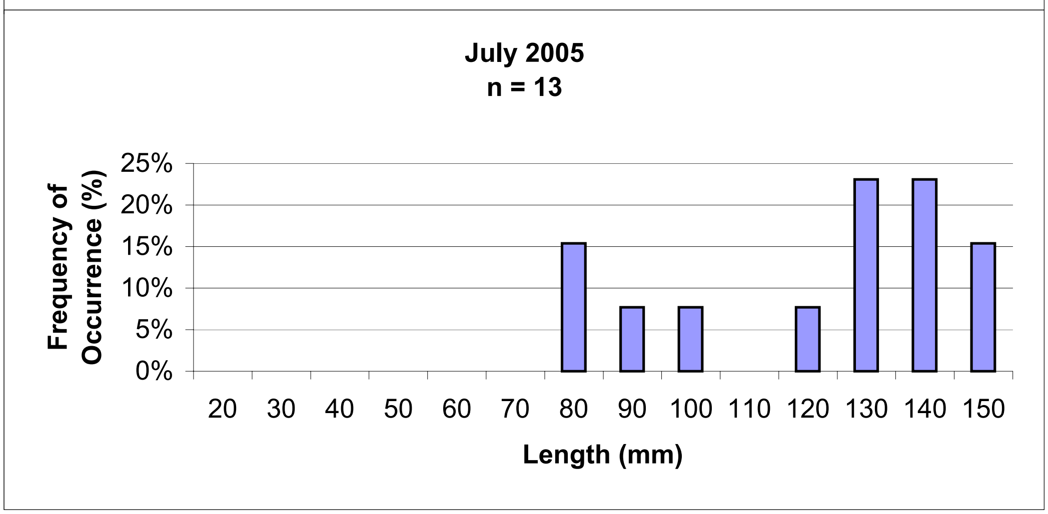
Length Frequencies of Sockeye Salmon in Port MacKenzie Fixed Tow Net



00214\012\Final Report 11-30-2005\Fig 22

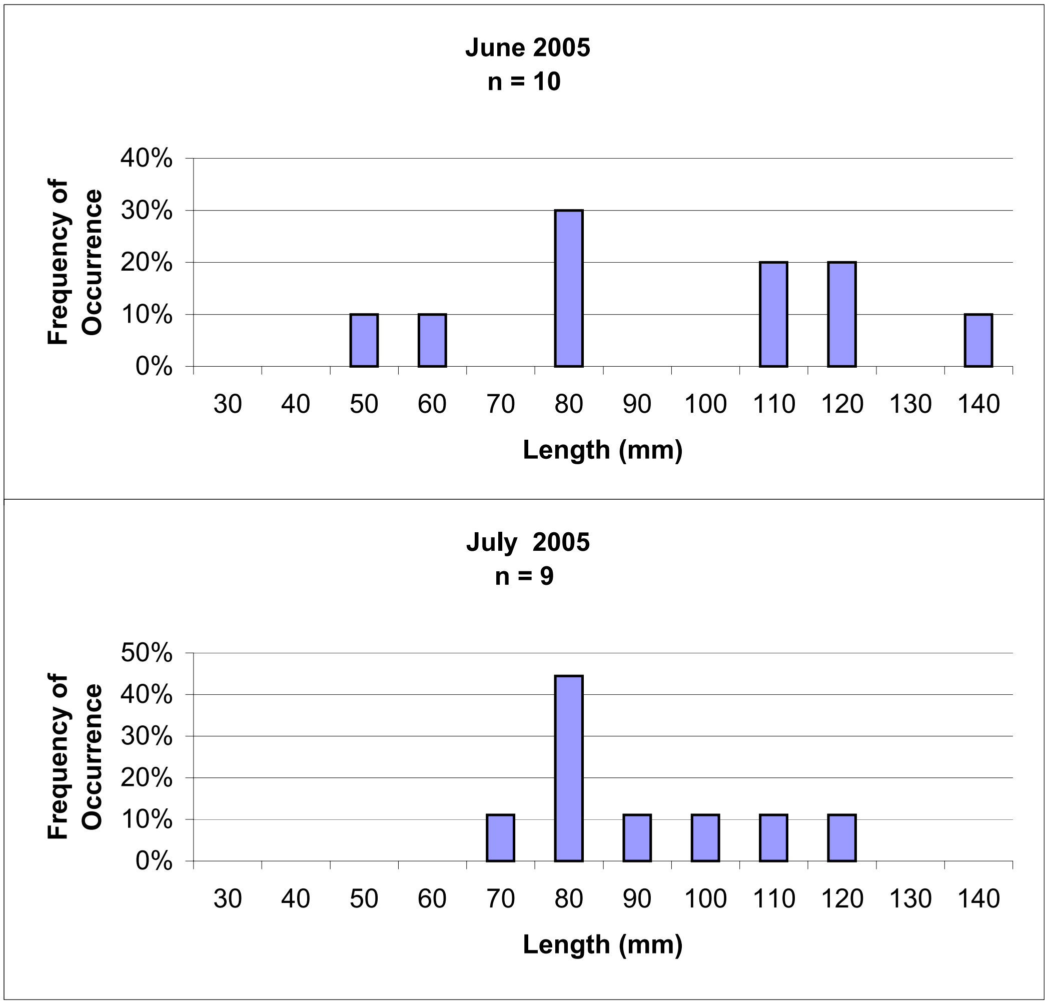
Length Frequencies of Coho Salmon in Port MacKenzie Fixed Tow Net





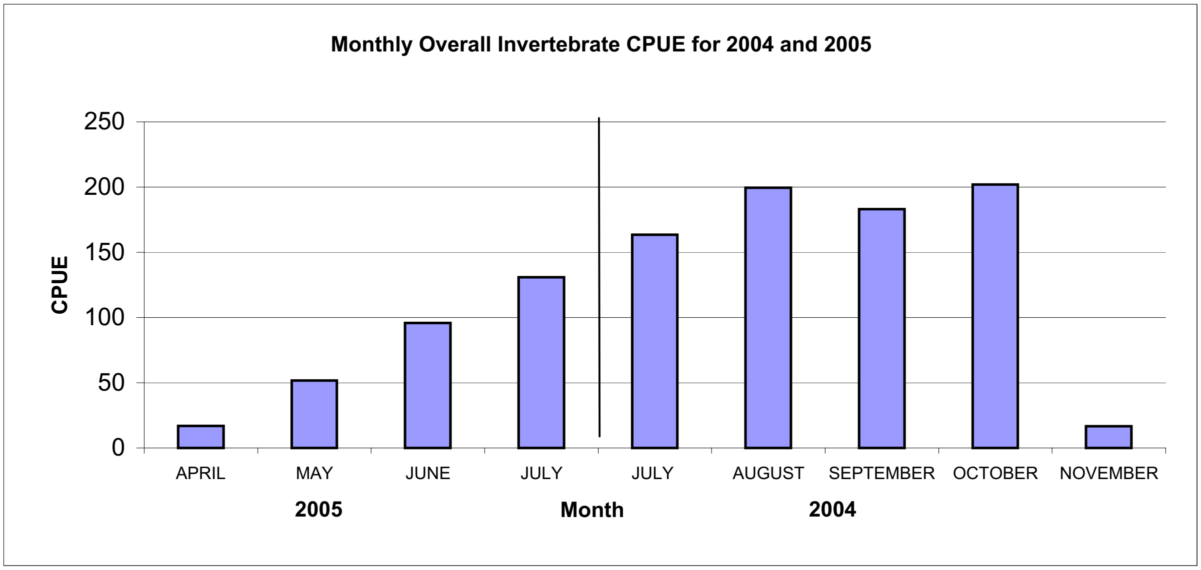
00214\012\Final Report 11-30-2005\Fig 23

Length Frequencies of Chinook Salmon in Port MacKenzie Fixed Tow Net



00214\012\Final Report 11-30-2005\Fig 24

Monthly Invertebrate CPUE in 2004 and 2005; 120-Foot Beach Seine



00214\012\Final Report 11-30-2005\Fig 25

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Figure 25

Invertebrate CPUE by Species in 2004 (right) and 2005 (left); 120-Foot Beach Seine

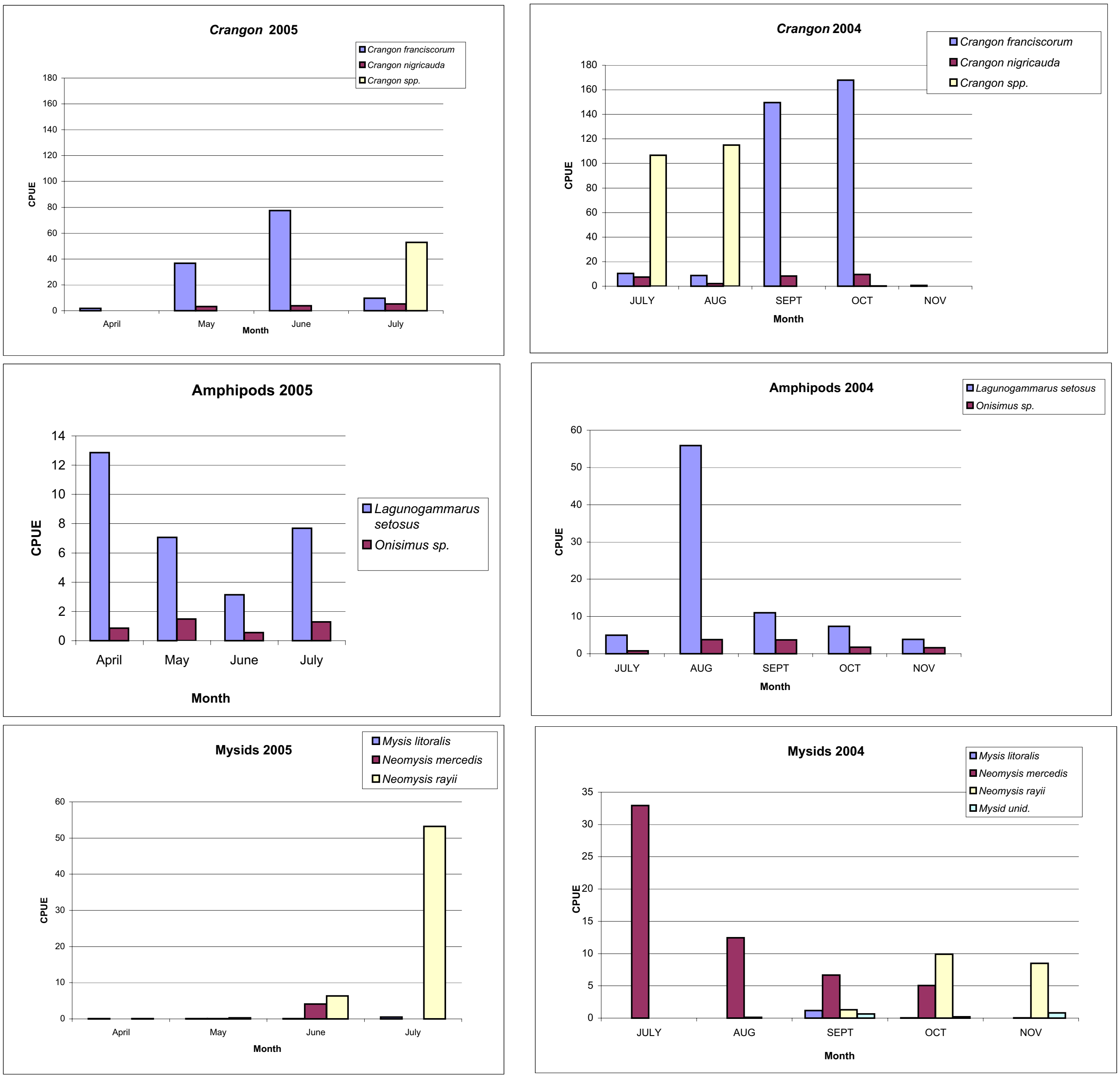

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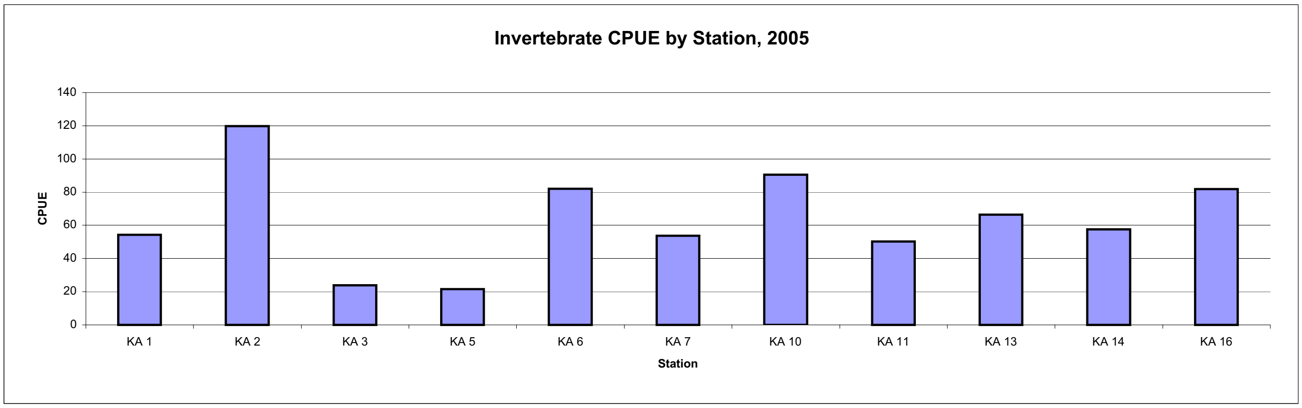
Figure 26

Invertebrate CPUE by Station in 2005; 120-Foot Beach Seine



00214\012\Final Report 11-30-2005\Fig 27

PENTEC ENVIRONMENTAL

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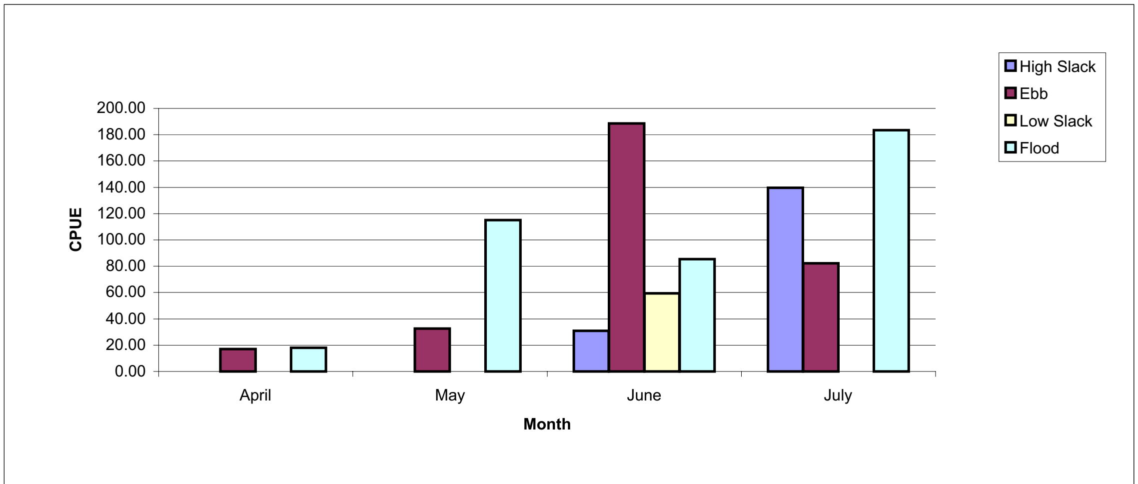
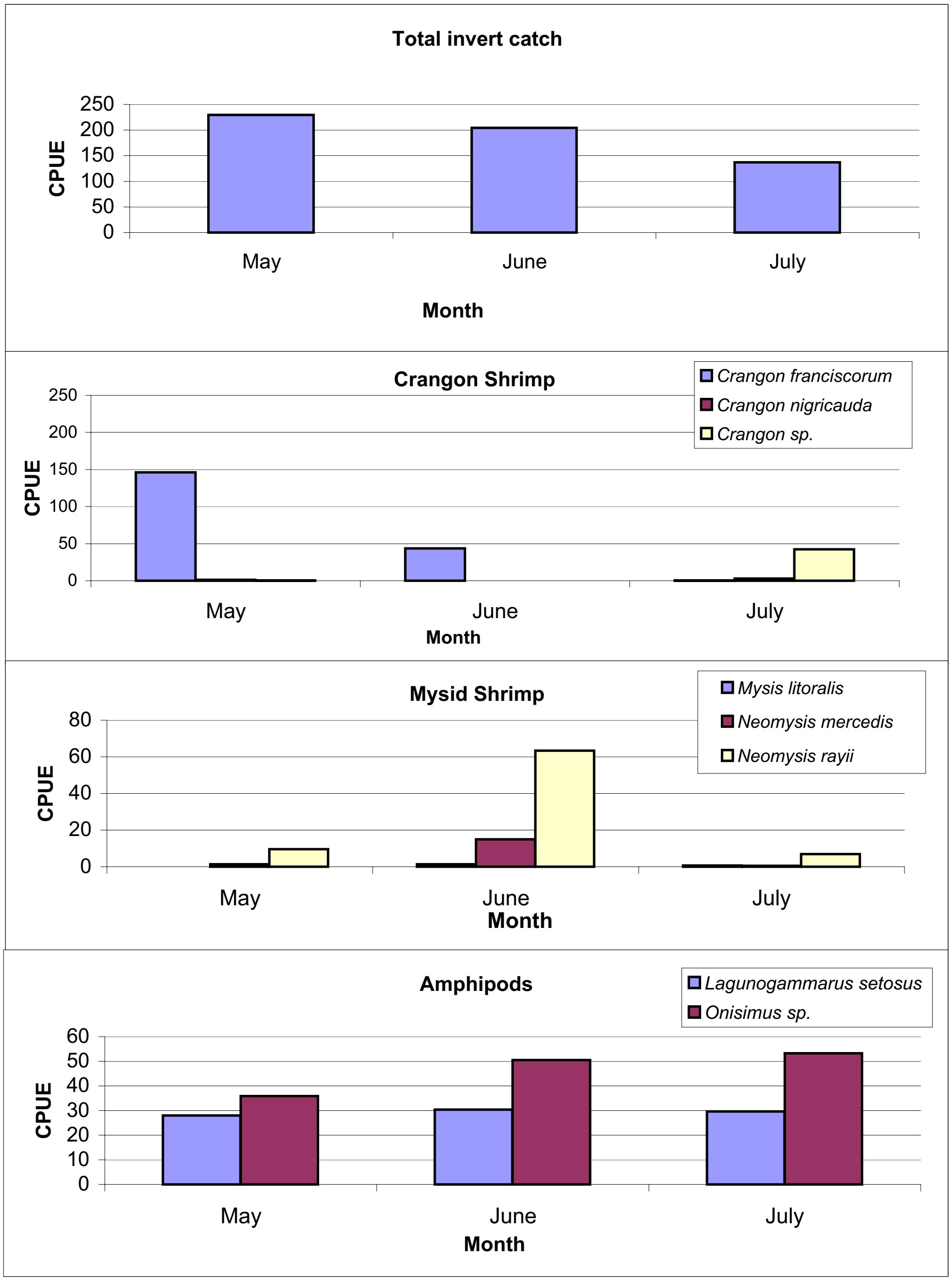
Figure 27

Relationship of Tidal Stage and Invertebrate CPUE; 120-Foot Beach Seine



00214\012\Final Report 11-30-2005\Fig 28

Invertebrate CPUE by Month in 2005 - Tow Net



00214\012\Final Report 11-30-2005\Fig 29

PENTEC ENVIRONMENTAL

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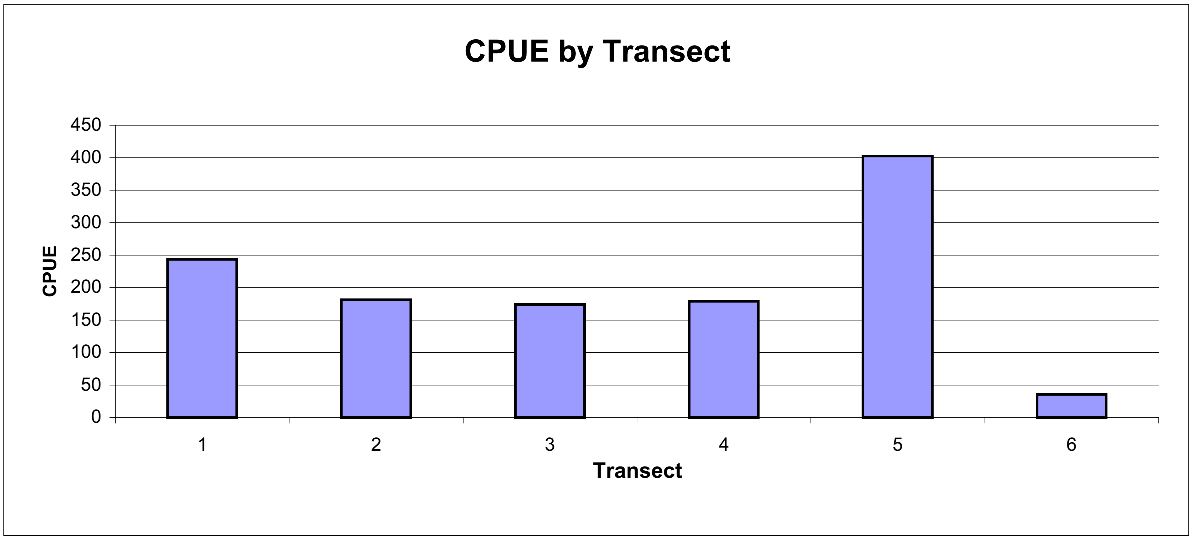
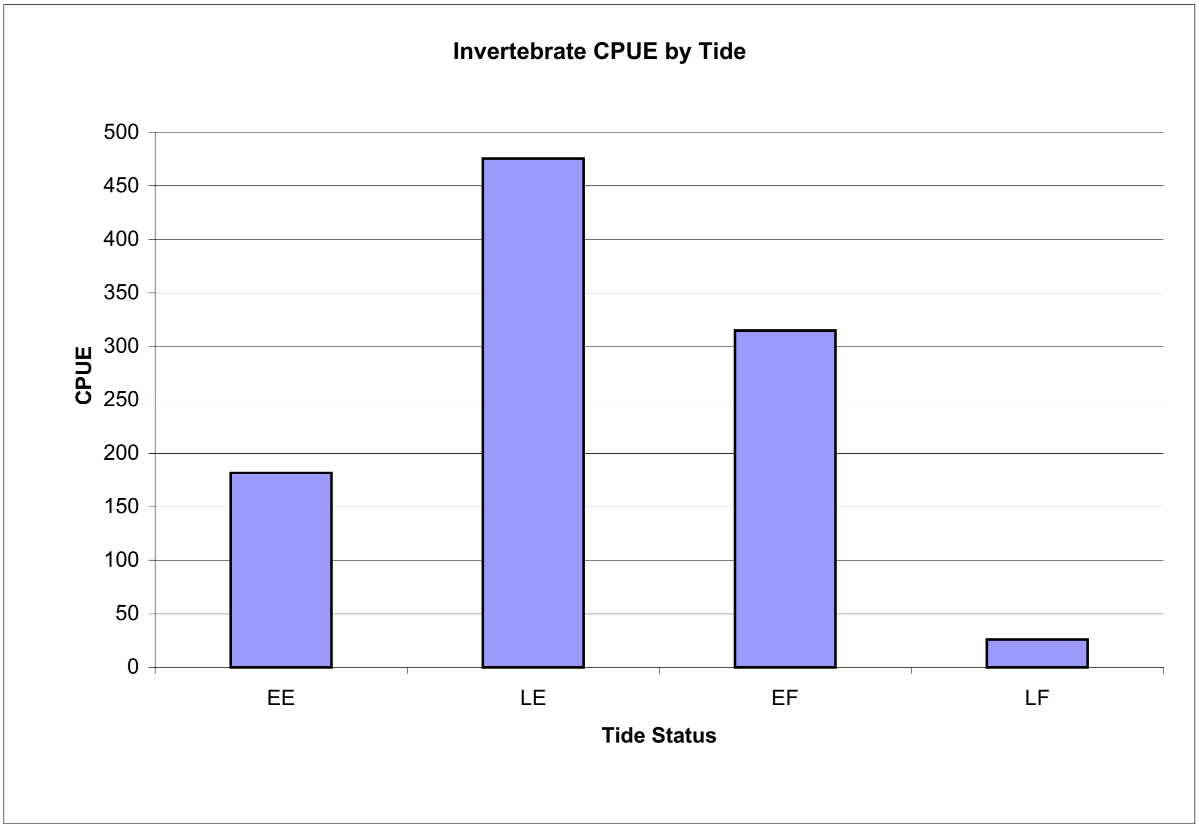
Figure 29

Invertebrate CPUE by Transect in 2005; Tow Net



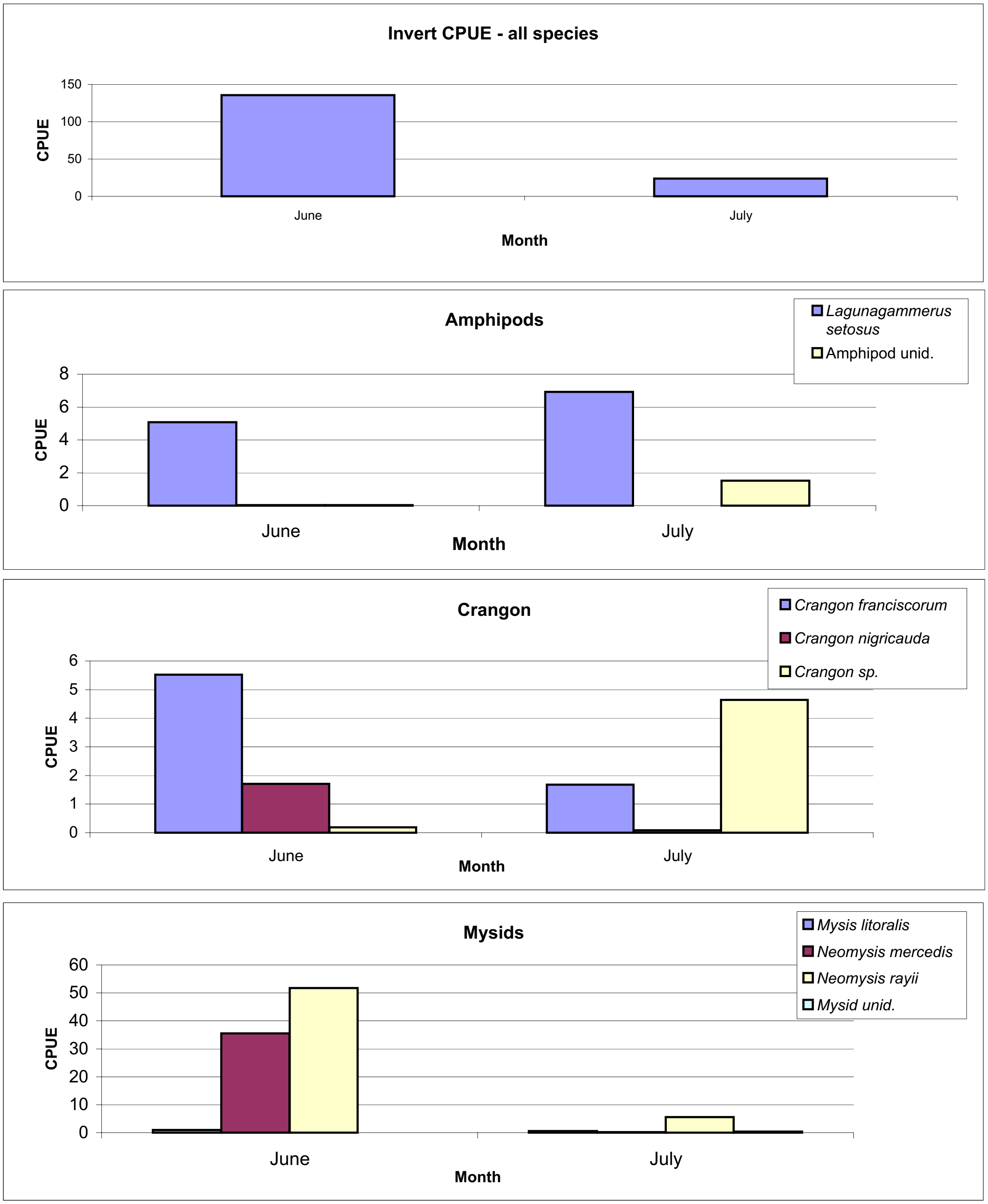
00214\012\Final Report 11-30-2005\Fig 30

Invertebrate Total Catch by Tide Status in 2005; Port MacKenzie Fixed Tow Net



00214\012\Final Report 11-30-2005\Fig 31

Invertebrate Monthly CPUE in Port MacKenzie Fixed Tow Net



00214\012\Final Report 11-30-2005\Fig 32

PENTEC ENVIRONMENTAL

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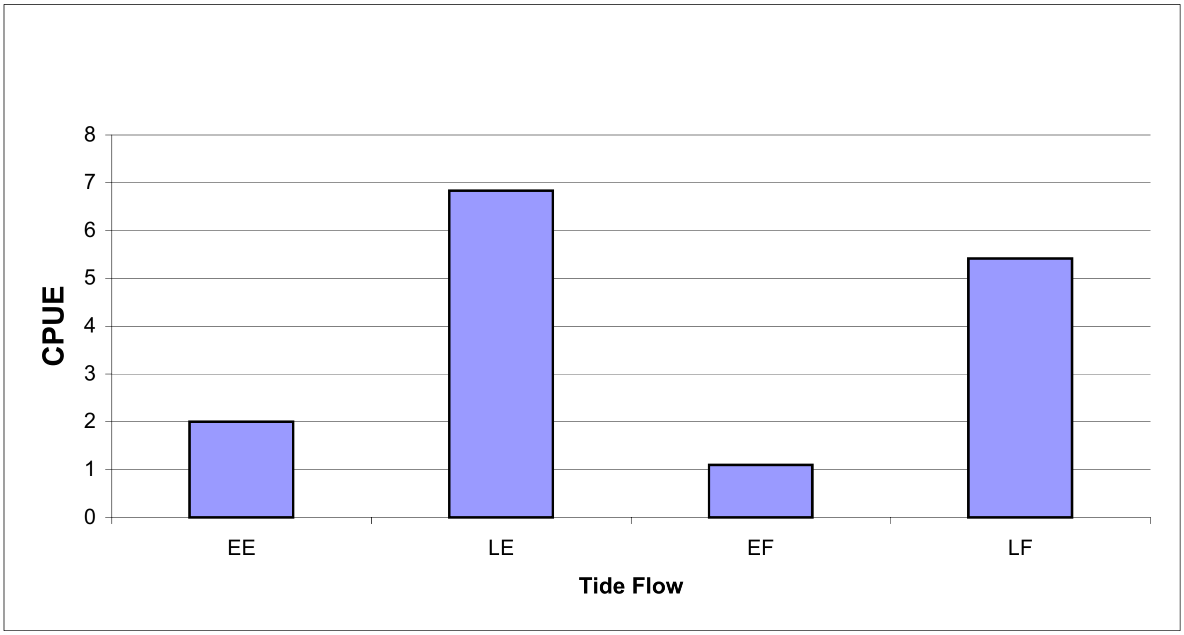
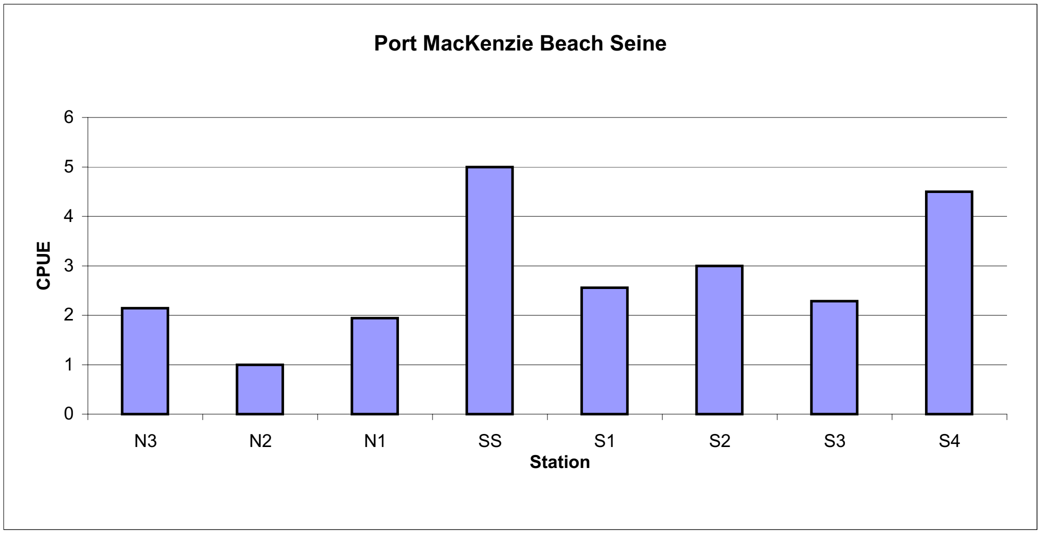
Figure 32

Invertebrate CPUE by Tide - Port MacKenzie 30-Foot Seine



00214\012\Final Report 11-30-2005\Fig 33

Invertebrate CPUE by Station; Port MacKenzie 30-Foot Seine



00214\012\Final Report 11-30-2005\Fig 34

PENTEC ENVIRONMENTAL

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Figure 34

PHOTOGRAPHS

Photo 1 - Beach seine haul at Station KA 7, July 2004.

Photo 2 - Tow net deployed from Port MacKenzie trestle, position PM 00, July 2005.

Photo 3 - 30-foot beach seine deployed at Station MP N1, July 2005.

Photo 4 - Station KA 3, looking northeast, November 2004.

Photo 5 - Station KA 5A, looking north, November 2004.

Photo 6 - Station KA 6B, looking west, May 2005.

Photo 7 - Station KA 7A, looking east, July 2004.

Photo 8 - Station KA 7B, looking southwest, July 2004.

Photo 9 - Station KA 10, looking west, May 2005.

Photo 10 - Processing catch at Station KA 11, looking south, July 2004.

Photo 11 - Station KA 13, looking north, July 2004.

Photo 12 - Station KA 14, low tide, July 2004.

Photo 13 - Station KA 14, blue-green algae on mid-beach, July 2004.

Photo 14 - Station KA 16, lower beach face, May 2005.

Photo 15 - Station KA 16, Rockweed on boulder, July 2004.

Photo 16 - PM SS and PM S1 from offshore, July 2005.

Photo 17 - Visible tracks of Neanthes limnicola in a burrow at Station KA 14.

Photo 18 – Station KA 16, scoured sand and silts on lower flat, July 2004.

APPENDIX A
MONTHLY FIELD SUMMARIES

MEMORANDUM

DATE: August 13, 2004

TO: Robin Reich, HDR Alaska, Inc.

FROM: Jon Houghton, Jim Starkes, Pentec Environmental

RE: **Summary of July Sampling Activities – Knik Arm, Alaska**
12214-10

CC: Kevin Doyle, HDR Alaska, Inc.

Intertidal and littoral habitats in Knik Arm were sampled during the period of July 25 through July 28, 2004. Fish and benthic samples were collected by beach seine, otter trawl, and intertidal cores at the following six stations:

South side of Arm:

- Station 7 southwest of Eagle Bay
- Station 11 at Cairn Point
- Station 13 at Point Woronzof

North side of Arm:

- Station 10 south of Goose Creek
- Station 14 northeast of Port MacKenzie
- Station 16 northeast of Point MacKenzie

Stations 7 through 13 corresponded to stations sampled in 1983 for the Knik Arm Marine Studies Report.

Most fish observed during sampling activities were captured using the beach seine. Two sets were made at each station and most stations were sampled twice—once during a high flooding tide and once during a low ebbing tide. More fish were captured at higher tidal elevations during a flooding tide. Table 1 presents a summary of the fish species captured during beach seine sampling.

Table 1 - Fish Species Observed during Beach Seine Activities at Knik Arm

Species	Station					
	7	10	11	13	14	16
Chinook salmon						
Juvenile		x	x		x	x
Adult						
Coho salmon						
Juvenile	x	x	x	x		x
Adult	x	x	x		x	x
Chum salmon						
Juvenile		x				
Adult					x	
Pink salmon						
Juvenile		x				
Adult		x	x			
Sockeye salmon						
Juvenile	x	x	x		x	x
Adult	x	x		x	x	
Threespine stickleback	x	x	x	x	x	X
Ninespine stickleback	x	x	x	x	x	x
Saffron cod	x	x		x	x	x
Pacific staghorn sculpin					x	
Longfin smelt	x		x	x	x	
Prickleback			x			

Threespine and ninespine stickleback were observed at all 6 stations and were the most abundant fish species collected during seining activities. Adult salmon were captured at most stations with coho (silver) the most prevalent, followed by sockeye (red), and pink salmon. One adult chum salmon and no adult chinook salmon were captured. Juvenile salmon were also observed at all stations with juvenile chinook and coho most prevalent followed by sockeye. Relatively few juvenile pink and chum salmon were observed in beach seine sets.

Other non-salmonid species observed with regularity in beach seine sets include longfin smelt and saffron cod. Prickleback and Pacific staghorn sculpin were relatively rare in beach seine sets. Numerous juvenile crangonid shrimp and epibenthic amphipods were also captured in beach seine sets and preserved for later laboratory identification.

Five of the six stations were also sampled by otter trawl. The trawl net was towed parallel to the shore for 5-minutes in the shallow littoral zone at each of the stations sampled. Only one adult starry flounder was captured during trawl sampling. Crangonid shrimp and a few other epibenthic invertebrate species were also captured and preserved for later laboratory identification.

Three surface core sediment samples were collected approximately 1 foot from the waters edge at each of the six stations to collect benthic and epibenthic invertebrates. Invertebrates collected were preserved for later laboratory identification. Relatively few invertebrates were observed in sediments, with the principal taxon being polychaete worms.

The August sampling is planned for August 23 through 25, 2004.

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MEMORANDUM

Anchorage
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DATE: October 6, 2004

TO: Robin Reich, HDR Alaska, Inc.

FROM: Jon Houghton, Jim Starkes, Pentec Environmental

RE: **Summary of August Sampling Activities – Knik Arm, Alaska**
12214-10

Intertidal and littoral habitats in Knik Arm were sampled during the period of August 23 through August 25, 2004. Fish and benthic samples were collected by beach seine and intertidal cores at the following nine stations:

Regular stations:

- Station 13 at Point Woronzof
- Station 16 Northeast of Point MacKenzie
- Station 14 North of Port MacKenzie
- Station 11 North side of Cairn Point
- Station 7A Southwest of Eagle Bay
- Station 10 South of Goose Creek

Additional stations:

- Station 1 Near the mouth of Fire Creek
- Station 3 Northeast of Eagle Bay
- Station 7 Southwest entrance to Eagle Bay

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Stations 3, 7, 10, 11, and 13 corresponded to those areas sampled in 1983 for the Knik Arm Marine Studies Report.

Fish observed during sampling activities were captured using the beach seine. Table 1 presents a summary of the fish species captured during beach seine sampling.

Table 1 - Fish Species Observed during Beach Seine Activities at Knik Arm

Species	Station								
	1	3	7a	7	10	11	13	14	16
Chinook salmon									
Juvenile					X	X	X		X
Adult									
Coho salmon									
Juvenile			X	X		X			X
Adult	X			X	X	X	X		
Chum salmon									
Juvenile									
Adult									
Pink salmon									
Juvenile									
Adult									
Sockeye salmon									
Juvenile	X	X	X	X	X		X	X	X
Adult									
Threespine stickleback	X	X	X	X	X	X	X	X	X
Ninespine stickleback	X	X	X	X	X	X		X	X
Saffron cod	X		X	X	X	X		X	X
Pacific staghorn sculpin			X						
Longfin smelt						X	X	X	
Prickleback									

Threespine and ninespine stickleback were the most common fish species observed during seining activities, followed by juvenile salmonids. The composition of salmonids was somewhat different then those observed during the July sampling period. Fewer adult salmon were captured and all were coho salmon, compared with the July sampling effort in which coho, sockeye, pink, and chum adults were observed. Of the juvenile salmonids, sockeye were the most prevalent, followed by coho and chinook; while during July, coho and chinook were predominant.

Other non-salmonid species observed with regularity in beach seine sets include longfin smelt and saffron cod. Numerous juvenile *Crangon* shrimp and epibenthic amphipods were also captured in beach seine sets and preserved for later laboratory identification.

The otter trawl hung badly and was lost during the first set off Station 13; no otter trawl data were collected during the August sampling effort.

Three surface core sediment samples were collected approximately 1 foot from the water's edge at Stations 7, 10, 11, 13, 14, and 16. Invertebrates collected were preserved for later laboratory identification. As in July, relatively few invertebrates were observed in sediments, with the principal taxon being a polychaete worm.

A large pod of beluga whales (~40+ animals) was sighted between Eagle Bay and Eagle Bay Point. Upon spotting animals in binoculars, operations ceased until animals were out of sight. Field operations did not resume until it was confirmed by the LGL field team that the whales had moved out of the area.

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MEMORANDUM

DATE: October 6, 2004

TO: Robin Reich, HDR Alaska, Inc.

FROM: Jon Houghton, Jim Starkes, Pentec Environmental

RE: **Summary of September Sampling Activities – Knik Arm, Alaska**
12214-10

Intertidal and littoral habitats in Knik Arm were sampled during the period of September 20 through September 22, 2004. Fish and benthic samples were collected by beach seine and intertidal cores at the following seven stations:

Regular stations:

- Station 13 at Point Woronzof
- Station 16 Northeast of Point MacKenzie
- Station 14 North of Port MacKenzie
- Station 11 North side of Cairn Point
- Station 7A Southwest of Eagle Bay
- Station 10 South of Goose Creek

Port stations:

- Station 11A South side of Cairn Point

Stations 10, 11, and 13 corresponded to those areas sampled in 1983 for the Knik Arm Marine Studies Report. Each regular station was sampled on two consecutive days to evaluate the influence of tide stage on catch. A new station (11A), added under contract to the Port of Anchorage (ICRC), was seined on September 21. This area was found to be

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badly fouled with old metal, glass and wood eroding from the adjacent bluff, making it difficult to properly fish the net.

Fish observed during sampling activities were captured using the beach seine. Table 1 presents a summary of the fish species captured during beach seine sampling.

Table 1 - Fish Species Observed during Beach Seine Activities at Knik Arm

Species	Stations						
	7A	10	11a	11	13	14	16
Chinook salmon							
Juvenile	X	X					
Adult							
Coho salmon							
Juvenile	X	X		X	X		
Adult							
Chum salmon							
Juvenile							
Adult							
Pink salmon							
Juvenile							
Adult							
Sockeye salmon							
Juvenile	X	X					
Adult			X				
Threespine stickleback	X	X	X	X	X		
Ninespine stickleback	X	X			X		
Saffron cod				X	X	X	X
Bering Cisco							X
Longfin smelt	X	X		X	X		X
Pacific herring	X	X			X		
Clingfish	X						

Stickleback and saffron cod were the most common fish species observed during seining activities, followed by juvenile salmonids. The composition of salmonids was somewhat different then those observed during the summer sampling periods. Only a single adult salmon was captured and this fish was badly injured probably from an encounter with a gill net. Juvenile salmon were less abundant than during summer sampling. Of the juveniles, coho were most prevalent in September with very few chinook and sockeye.

Other non-salmonid species observed with regularity in beach seine sets include longfin smelt and juvenile Pacific herring. Herring were observed for the first time during the September sampling event. Other species observed for the first time include Bering cisco and a species of clingfish. Numerous juvenile *Crangon* shrimp and epibenthic amphipods were also captured in beach seine sets although fewer relative to summer sampling events. More adult Crangon shrimp were observed during the September sampling event.

Three surface core sediment samples were collected approximately 1 foot from the waters edge at Stations 7, 10, and 11. Invertebrates collected were preserved for later laboratory identification. Similar to summer sampling, relatively few invertebrates were observed in sediments, with the principal taxa being polychaete worms. All six stations have now been sampled at both the upper and lower intertidal zones and similar sparse communities have been observed at all stations and elevations. As a result, we do not plan on additional infaunal sampling until next spring.

One or two beluga whales were sited at two locations in the project area (off Point MacKenzie and at Station 14 north of Port MacKenzie. Upon spotting the animals, operations ceased until animals were out of site. Field operations did not resume until it was confirmed by the LGL field team that the whales had moved out of the area.

MEMORANDUM

DATE: November 11, 2004

TO: Robin Reich, HDR Alaska, Inc.

FROM: Jon Houghton, Jim Starkes, Pentec Environmental

RE: **Summary of October Sampling Activities – Knik Arm, Alaska**
12214-10/12618-01

CC: Diana Brake, ICRC

Intertidal and littoral habitats in Knik Arm were sampled during the period of October 20 to 23, 2004. Fish samples were collected by beach seine at the following nine stations:

- Station 13 at Point Woronzof
- Station 16 East of Point MacKenzie
- Station 14 East of Port MacKenzie
- Station 11 at Cairn Point
- Station 11A south of Cairn Point near the northern boundary of the Port of Anchorage
- Station 7A Southwest of Eagle Bay
- Station 10 South of Goose Creek
- Station PS1 Port of Anchorage property landward of the Port Offices, south of Trestle No. 1
- Station PS2 Port of Anchorage property, south of fuel dock POL-2

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Stations 10, 11, and 13 corresponded to those areas sampled in 1983 for the Knik Arm Marine Studies Report. Two beach seine sets were made at each station. Table 1 lists all species/life history stages of fish captured.

Table 1 - Fish Species Captured in October Beach Seining

	KABATA Stations						Port Stations		
	16	14	10	7A	11	13	11A	PS1	PS2
Chinook salmon									
Juvenile		X							
Adult									
Coho salmon									
Juvenile			X				X		
Adult									
Chum salmon									
Juvenile									
Adult									
Pink salmon									
Juvenile									
Adult									
Sockeye salmon									
Juvenile			X	X	X		X		
Adult									
Threespine stickleback			X	X	X	X		X	X
Ninespine stickleback		X	X	X	X	X	X	X	X
Saffron cod	X	X	X	X	X	X	X	X	X
Bering Cisco									
Longfin smelt	X	X	X	X	X	X	X		X
Pacific herring		X	X	X	X	X	X		
Clingfish (Liparidae)	X	X	X	X	X		X		
Starry flounder							X		

The composition and abundance of fish in beach seine catches had shifted relative to the summer sampling events. Juvenile salmonids were no longer abundant, and of those observed, most were small sockeye between 53 and 63 mm fork length. The dominant species was larval longfin smelt, which were observed at all but one station. Most of these fish were transparent, measuring between about 50 and 75 mm fork length, and were quite abundant at some of the stations. Adult smelt up to 160 mm were also observed at most stations, but in fewer numbers. October sampling also found the largest number of clingfish relative to previous sampling events. Saffron cod were found at all stations in moderate numbers. Three and ninespine stickleback were found in moderate numbers at most stations, but their abundance appeared to be lower then previous sampling events when they were usually the most abundant species. Juvenile Pacific herring were also observed six stations, but usually no more than one or two individuals per set. One adult starry flounder was captured at Station 11A on the northern boundary of the Port of Anchorage.

Invertebrates composed of *Crangon* shrimp, mysid shrimp, and amphipods were found at varying abundances at all stations. As during the summer sampling, large numbers were still observed at some stations, but other stations had relatively few. All were preserved for laboratory identification and enumeration.

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MEMORANDUM

Anchorage

DATE: November 22, 2004

TO: Robin Reich, HDR Alaska, Inc.
Bill Humphries, Diana Brake, Integrated Concepts and Research Corporation

FROM: Jon Houghton, Jim Starkes, Pentec Environmental

Denver

RE: **Summary of November 8-10, and 16-17, 2004 Sampling – Knik Arm, Alaska**
12214-10/12618-01

Shorelines of Knik Arm were sampled on November 8, 16, and 17, 2004. A total of 18 beach seine sets were made at the following stations (dates and number of sets in parentheses):

Edmonds

- Station 5A – North side of Eagle Bay (11/17, 1 set)
- Station 7 Southwest of Eagle Bay (11/17, 1 set)
- Station 7A Southwest of Station 7 (11/17, 1 set)
- Station 10A South of Station 10A (11/8, 1 set; 11/16, 1 set)

Philadelphia

- Station 11 at Cairn Point (11/8, 2 sets; 11/16, 2 sets)
- Station 11A south of Cairn Point near the northern boundary of the Port (11/16, 2 sets)
- Station 14 – North of Port MacKenzie (11/16, 1 set)
- Station 16 – Northeast of Point MacKenzie (11/16, 2 sets)

Portland

- Station PS-2 Port of Anchorage property, south of fuel dock POL-2 (11/16, 2 sets)
- Station PS-3 South of Boat Launch (11/16, 2 sets)

Fish species captured in beach seining during this sampling period are identified in Table 1.

Table 1 - Fish Species Observed during Beach Seining in Knik Arm, November 2004

	KABATA Stations							Port Stations		
	16	14	10A	5A	7	7A	11	11A	PS2	PS3
No Fish		X							X	X
Chinook salmon										
Juvenile										
Coho salmon										
Juvenile	X		X							
Threespine stickleback					X					
Ninespine stickleback	X			X		X				
Saffron cod	X			X			X			
Longfin smelt							X			
Clingfish (Liparidae)								X		

The initial attempt at sampling in the Arm in November was abbreviated because of severe weather and ice. On November 8, winds were light and the Arm was calm, but launch of the boat and skiff was delayed due to ice accumulations at the boat launch and floating ice within the Arm. The Port of Anchorage deployed a front loader to clear the launch of shore ice and the boats were launched on a flooding tide. Once launched, sampling efforts were delayed to allow the flooding tide to clear floating ice from stations north of Ship Creek. Station 11 (Cairn Point) was sampled in a relatively normal manner, completing two sets at mid-tidal elevations (~+17 feet). To avoid off shore ice, the 100-foot haul lines on each end of the net were only deployed to about 75 feet. A substantial amount of ice was piled at upper tidal elevations, but did not interfere with seining since the flooding tide had not yet reached the piles of ice. The beach gravels were frozen. Fish composition and abundance were substantially lower relative to previous sampling conducted during the summer and early fall. Approximately 12 adult longfin smelt and one saffron cod were captured in the two sets. No sticklebacks, juvenile salmonids, or liparids (clingfish), common in October, were captured. The number of invertebrates was also substantially lower then previous sampling, composed of juvenile *Crangon* shrimp, mysid shrimp, and amphipods.

After sampling Station 11, the sampling team headed north up the Arm toward Station 7A, near the southern edge of Eagle Bay. At Station 7A, the rising tide had reached the substantial amount of ice layered at mid- to upper tidal elevations. No natural beach was showing and the ice was soft and broke up when stepped on, releasing ice and slush into the water and making it impossible to attempt a set. The team then proceeded to the northern shore of the Arm to Station 10. Piles of ice within the mid- to upper intertidal zone were not as prevalent on the northern shore, but substantial amounts of floating cake and slush ice were present in the nearshore. Station 10 proper could not be sampled because floating ice. A break in the ice was present at a position approximately 400 meters south of Station 10 and a shallow set was attempted. Upon retrieval, the net quickly filled with skim ice, slush, and unavoidable floating ice; no fish and only a few invertebrates were captured. A second set was not attempted at this area, because of encroaching floating ice.

Proceeding south, Stations 14 and 16 on the northern shore of the Arm were iced in and could not be accessed. Crossing the Arm, the team examined Site 11A, south of Cairn Point near the Port of Anchorage's northern boundary, but the tide had reached the upper intertidal zone, was iced in, and could not be sampled.

The sampling team next assembled at the Ship Creek boat launch on the morning of November 9, but encountered a near continuous 30 to 40 knot north wind; the sampling event was scrubbed due to the severe weather and hazardous conditions. The Arm was again examined at the boat launch during the early afternoon after the wind had subsided. Thick floating ice was present along the south shore from the intertidal zone out to as far as halfway across the Arm. Floating ice was near continuous from Point Woronzof to Cairn Point; traversing the Arm could not be conducted safely so it was again decided to scrub the sampling event. During the afternoon flood, Trestle 1 at the Port was also examined for possible deployment of the tow net. The area was sufficiently iced in with floating ice that the net could not be deployed.

On November 10, we visited the boat launch twice in the early morning (0645 and 0745) and found ice conditions that again would prevent launching or movement to sampling stations to the north and south. We also looked at conditions at the Port and found sufficient ice to prohibit safe net deployment. Mud beaches in and around the Port and south of the boat launch (Port Sites 1 through 3), which can only be sampled at high tides (e.g., +27 feet MLLW or higher) were covered with ice cakes and could not be seined.

Sampling attempts were terminated until November 16 when the crew re-mobilized after a period of several days of warmer temperatures. Again, it was necessary to have the Port clear ice from the ramp in order to launch boats, but there was much less floating ice and much less ice on the shorelines at potential sampling locations. Water temperatures in the Arm ranged from −0.2 ºC to +0.3 ºC. Sampling was possible at several stations, although not without some struggles with frozen beaches that tended to snag the nets and make footing uncertain. Of particular note was the set made at Station 10A (Station 10, again having too much floating ice to access): The bag (fine mesh portion of the net) contained a very large volume of a semi-frozen mud/plant fiber slurry, quite unlike anything hauled in before. This material made it impossible to find any invertebrates that may have been present, but two juvenile coho salmon, both 90 mm, were present. Coho were also taken at Station 16, just north of Point MacKenzie, along with several adult saffron cod. Falling tides and ice conditions prevented boat retrieval until about 10 pm, and the larger boat and trailer were damaged by ice during recovery.

On November 17, road conditions, ice on the ramp, and poor visibility on the Arm delayed launching until 1100 hours. With a Beluga observer on board, we navigated to the north side of Eagle Bay (Station 5) with the intent of seining in areas known to be frequented by whales. Large chunks of ice along the shoreline prevented sampling. We then cruised south and east into Eagle Bay. The northern shore of the bay consists of a high and unstable bluff and a very steep beach, again with large amounts of moving ice, such that.seining could not be safely accomplished. A more gradual beach was found at the mouth of a small ravine and creek entering the north side of Eagle Bay. A set, carefully timed to avoid masses of moving ice was completed here (designated Station 5A), and yielded an adult saffron cod. Consistent presence of cod at several stations during the October and November sampling suggests that this species may comprise a primary food of belugas in the Arm after adult salmon runs have ended.

Logistical difficulties and vessel and personnel safety concerns associated with winter sampling in the Arm may preclude further sampling until spring breakup.

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MEMORANDUM

Anchorage
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DATE: May 13, 2005

TO: Robin Reich, HDR, Alaska, Inc.

FROM: Jon Houghton, Jim Starkes, Pentec Environmental

RE: **Summary of April Sampling Activities – Knik Arm, Alaska**
12214-12

CC: Kelly Barrett, Pentec Environmental

Intertidal and littoral habitats in Knik Arm were sampled during the period of April 19 to 21, 2005. This period represented the first sampling event of the 2005 spring/summer sampling season in the Arm. The Arm was relatively free of ice during this period, although a few pieces were still observed in the water and piled within the upper intertidal zone. The presence of ice did not provide a significant impediment to sampling. Fish samples were collected by at the following eight stations:

- Station 11, Cairn Point North
- Station 11A, Cairn Point South
- Station 16, East of Point MacKenzie
- Station 14, South of Port MacKenzie
- Station 13, Point Woronzof
- Station 7, Southern edge of Eagle Bay
- Station 7A, Southwest of Eagle Bay
- Station 10 South of Goose Creek

Each of the stations were sampled at least twice during the 3-day period. As with last years, late-summer to early winter sampling, all fish were captured and enumerated using a 120-

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foot floating beach seine. Salinity, temperature, and turbidity measurements were also collected at each station. Table 1 presents a summary of the fish species captured by beach seine during the April sampling event.

Table 1 - Fish Species Observed during Beach Seine Activities at Knik Arm

	Stations							
	16	14	10	7	11	13	7A	11A
Chinook salmon								
Juvenile								
Adult								
Coho salmon								
Juvenile						X	X	
Adult								
Chum salmon								
Juvenile				X				
Adult								
Pink salmon								
Juvenile								
Adult								
Sockeye salmon								
Juvenile					X			
Adult								
Threespine stickleback		X		X	X	X	X	X
Ninespine stickleback		X	X	X	X	X	X	X
Saffron cod	X	X	X	X	X	X	X	X
Bering Cisco								
Longfin smelt								X
Pacific herring								
Clingfish				X		X		
Starry flounder								
Eulachon			X					
Dolly Varden char				X				

Temperatures ranged from 2.7 to 4.8 degrees C, with the warmer measurements observed in the afternoon. Salinities were significantly higher that that observed last summer and fall, ranging from 17.8 to 20.1 parts per thousand. As expected, nearshore waters were very turbid, ranging from 260 to 850 ntu.

The number of both fish and invertebrates was significantly lower then that observed during last summer and fall, but more than observed in November 2004. Threespine stickleback, ninespine stickleback and saffron cod were the most common species, observed at most stations. All stickleback observed in April were adults, while a significant number of young-of-the-year and juveniles were observed last summer and fall. Both adult and juvenile cod were observed in April and last year. However, a significantly larger number of cod were observed at Station 10 (south of Goose Creek) compared with the other stations. Cod dominated the catch at this station, with little else observed. Although cod were common throughout the Arm, no such large aggregations of the species was observed last year.

Juvenile salmonids were relatively scarce during the April sampling event. Only a few juvenile chum, coho, and sockeye juveniles were captured. No adult salmon were observed, although one Dolly Varden char was captured. A few adult eulachon (hooligans) were captured in April; this species of smelt was not observed last summer and fall.

MEMORANDUM

DATE: June 16, 2005

TO: Robin Reich, HDR, Alaska, Inc.

FROM: Jon Houghton, Jim Starkes, Pentec Environmental

RE: **Summary of May Sampling Activities – Knik Arm, Alaska**
12214-12

CC: Kelly Barrett, Pentec Environmental

Intertidal and littoral habitats in Knik Arm were sampled by beach seine during two periods in May (May 5-7 and 18-21). The Arm was free of ice during both periods. Fish samples were collected at the following 9 stations:

- Station 11A, Cairn Point South
- Station 16, East of Point MacKenzie
- Station 14, South of Port MacKenzie
- Station 13, Point Woronzof
- Station 7, Southern edge of Eagle Bay
- Station 7A, Southwest of Eagle Bay
- Station 10 South of Goose Creek
- Station 3 Northern edge of Eagle Bay
- Station 5A Mouth of Goose Creek

Most of the stations were sampled at least once during both 3-day sampling periods. Because significant minus tides were experienced during sampling periods, sampling was often suspended during the late morning/early afternoon and recommenced in late-

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afternoon. However, sampling was conducted on the late ebb and early flood tides at Stations 13 and 11A (stations at which sampling could be conducted at lower tidal elevations) to compare catch rates at the same station during incoming and outgoing tides. Salinity, temperature, and turbidity measurements were also collected at each station.

During May 18-20, five transects were established and sampled in the middle of the Arm using a tow net to determine if juvenile salmon and other species occupy subtidal areas. The transects were established throughout lower Knik Arm at the following locations:

- Transect 1 - near the mouth of the Arm between Point Woronzof and Point MacKenzie
- Transect 2 - from a point north of Point MacKenzie to about the mouth of Ship Creek
- Transect 3 - from Port MacKenzie to a point south of Cairn Point
- Transect 4 - from about beach seine Station 10 running east across the Arm
- Transect 5 – a short northern transect offshore of seining stations 7 and 7A

Five equidistant stations were located along each transect (except Transect 5) and 5-minute tows were made at each to collect representative samples along the entire mid-channel reach of the Arm. Only two stations were located along the shorter Transect 5 which ended prior to reaching the shallow waters of Middle Shoal.

Table 1 presents a summary of the fish species captured by beach seine and Table 2 presents a summary of fish species captured by tow net during May.

Temperatures ranged from 6.7 to 12.5 degrees C, with the warmer measurements observed in the afternoon. Salinities ranged from 10.0 to 19.6 parts per thousand. As expected, nearshore waters were very turbid, ranging from 110 to 1,100 ntu. Most turbidities were over 300 ntu except for clearer water observed at Station 13 (Point Woronzof) near the mouth of the Arm.

In beach seine hauls, the number of both fish and invertebrates increased from that observed in earlier April sampling. Threespine stickleback and saffron cod were the most common species, observed at most stations. As in April, most all stickleback were adults, with just a few young-of-year showing. Both juvenile and adult cod were observed.

Juvenile salmon numbers in beach seine hauls increased relative to April sampling with juvenile chum the most abundant. Moderate numbers of juvenile pink salmon were also observed. During the May 18-21 period, larger hatchery Chinook salmon were found, particularly on the eastern side of the Arm. Post-spawn eulachon (hooligans) were moderately abundant in beach seine hauls.

In tow net samples, invertebrates and juvenile salmon dominated catch. Moderate numbers of juvenile chum and pink salmon were observed offshore at all transects. A few to moderate numbers of juvenile sockeye salmon were also observed offshore. Other species were relatively few in number but included threespine stickleback, smelt, herring, and larval flatfish.

Table 1 - Fish Species Observed during Beach Seine Activities at Knik Arm

	Stations								
	5A	16	14	10	7	3	13	7A	11A
Chinook salmon									
Juvenile				X			X	X	X
Adult									
Coho salmon									
Juvenile	X		X	X		X	X		
Adult									
Chum salmon									
Juvenile	X	X				X		X	
Adult									
Pink salmon									
Juvenile	X				X				
Adult									
Sockeye salmon									
Juvenile			X	X				X	
Adult									
Threespine stickleback	X	X	X	X	X	X		X	X
Ninespine stickleback						X			
Saffron cod		X	X	X	X	X		X	X
Bering Cisco									
Longfin smelt			X						
Pacific herring									
Clingfish	X								
Starry flounder									
Eulachon		X	X			X		X	X
Dolly Varden char									

Table 2 - Fish Species Observed during Tow Net Activities in Knik Arm

	Transect				
	1	2	3	4	5
Chinook salmon					
Juvenile					
Adult					
Coho salmon					
Juvenile	X				
Adult					
Chum salmon					
Juvenile	X	X	X	X	X
Adult					
Pink salmon					
Juvenile	X	X	X	X	X
Adult					
Sockeye salmon					
Juvenile	X	X	X	X	X
Adult					
Threespine stickleback		X	X	X	
Ninespine stickleback					
Saffron cod					
Bering Cisco					
Longfin smelt					
Pacific herring	X			X	
Clingfish					
Unidentified flatfish	X	X			
Eulachon	X	X	X	X	
Dolly Varden char					

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MEMORANDUM

DATE: July 8, 2005

TO: Robin Reich, HDR, Alaska, Inc.

FROM: Jon Houghton, Jim Starkes, Pentec Environmental

RE: **Summary of June Sampling Activities – Knik Arm, Alaska**
12214-12

CC: Melinda Chambers; Kelly Barrett, Pentec Environmental

SUMMARY OF JUNE SAMPLING ACTIVITIES

During the June sampling period, fish and invertebrate samples were collected by several methods over a two-week period, as follows:

Date	Sampling Method	Stations
June 14 – 15	120-ft Beach Seine	Beach Seine Stations 1, 2, 3, 6B, 7, 10, 11A, 13, 14, 16
June 16 –17	Active Tow Net	Tow Net Transects 1, 2, 3, 4, and 5. Stations 1, 2, 3, 4, and 5 at each transect (except Transect 5).
June 18 – 24	Passive Tow Net	Stations PM00, PM01, PM02 on Port McKenzie Pier
June 20 – 24	30 ft Beach Seine	Stations PMN, PMS, PMSS, PMNB, PMNB1, PMNA PMN

120-FT BEACH SEINE

Beach seining occurred at the six standard KABATA seining stations (Stations 7, 10, 11A, 13, 14, and 16) within outer Knik Arm, as well as at four additional stations (Station 1, 2, 3, and 6B) within the inner Arm on June 14 and 15, 2005. Station 1, located near the mouth of Fire Creek and Station 3, near Eagle Bay are inner Arm stations sampled occasionally when flooding tides allowed access and when whale monitors were available. Station 2 was a new station located between Goose Creek and Fish Creek, sampled because it was the nearest clean beach to a group of feeding beluga whales. Station 6B was located just south of the mouth of Goose Creek. Fish species observed in beach seine hauls are presented in Table 1.

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Table 1 - Fish Species Observed during June 2005 Beach Seine Activities at Knik Arm

	Stations									
	1	2	3	6B	7	10	11A	13	14	16
Chinook salmon										
Juvenile	X	X		X	X	X	X	X	X	X
Adult			X							
Coho salmon										
Juvenile	X	X	X	X	X	X	X		X	X
Adult										
Chum salmon										
Juvenile	X	X	X	X	X	X	X	X		X
Adult										
Pink salmon										
Juvenile										
Adult										
Sockeye salmon										
Juvenile	X		X	X	X	X	X	X	X	X
Adult										
Threespine stickleback	X	X	X	X	X	X	X	X	X	X
Ninespine stickleback					X					
Saffron cod	X		X		X		X	X		
Bering Cisco										
Longfin smelt	X	X		X	X	X	X	X		X
Pacific herring								X		X

Collectively, juvenile salmon were the dominant catch at most beach seine stations sampled in June, unlike previous sampling events this spring where threespine stickleback, saffron cod, or eulachon were most abundant. Stickleback and longfin smelt were moderately abundant at most stations; smelt actually dominated catch in some sets. Curiously, saffron cod were not highly abundant, either in total number or distribution. This species was observed at only 5 of the 10 stations sampled in June while it was widely distributed and abundant in May. No eulachon were observed in beach seine sets in June; spawned out individuals dominated catch in May. A few Pacific herring were observed, but only at the two southernmost stations (13 and 16).

Of the juvenile salmonids, sockeye were most abundant, followed by chum, Chinook, and coho salmon. All four species were observed at most stations. No pink juveniles were observed in June beach seine sets. Both wild and presumably hatchery-raised Chinook and coho salmon were observed. Hatchery fish were distinguished from wild principally by their larger size (90 – 110mm for Chinook; 100 – 130mm for coho). At least two juvenile life history trajectories for coho and sockeye salmon were observed. One young-of-the-year trajectory under 45 mm in length and larger older fish over 60 mm were observed for both species. One adult Chinook salmon (~780mm) was captured in a beach seine set at Station KA 3. Chinook were preserved from several stations for possible otolith and/or stomach content analysis using funding from the Port of Anchorage.

ACTIVE TOW NET

The five offshore transects established in May were again sampled on June 16 and 17 using a tow net to determine the degree to which juvenile salmon and other species occupy offshore areas of the Arm. As in May, five equidistant stations were located along each transect (except Transect 5) and 5-minute tows were made at each to collect representative samples along offshore portions of the Arm. Only two stations were located along the shorter Transect 5 which ended prior to reaching the shallow waters of Middle Shoal. An additional transect (Transect 6) was established within Eagle Bay and two stations were sampled on a high flooding tide.

Juvenile salmonids dominated catch at all tow net transects and stations. All five salmon species were observed with sockeye the most abundant by far. The number of sockeye juveniles captured in the tow net outnumbered all others combined. Juvenile chum salmon were second in abundance. Pink, coho, and Chinook juveniles were relatively scarce in tow net samples. The only other species observed in tow net samples were a few longfin smelt, eulachon, threespine stickleback, and larval flatfish.

FACILITY SAMPLING

From June 20 to 24, intensive sampling with the tow net and 30-ft beach seine was conducted on and near the Port McKenzie Pier facility to determine the relative abundance of juvenile salmonids as they migrate around the facility. Because the Port McKenzie Pier is located near the narrowest segment of Knik Arm, tidal currents at the facility can be strong, but were quite variable throughout the tidal cycle. When tidal currents were moderate to strong, the tow net was hung and fished passively in the current at three locations on the pier. Tow net sets were 5-minutes in duration and when possible, three replicate sets were made at each station. Station 00 was located nearest to shore along the pier caissons.

Station 01 was located midway between the shore and end of the pier, and Station 02 was located near the outer end of the pier. The tow net was fished on the south side of the pier during the ebbing tide and on the north side during a flooding tide.

Beaches adjacent to the pier facility were also sampled with a smaller 30-ft beach seine. This net was fished by deploying it perpendicular to shore, walking it upcurrent for length of approximately 100 ft., followed by pursing the net to the water's edge, forcing the catch into the cod end, situated in the center of the net. Three stations were located immediately north of the facility, three stations immediately south of the facility, and one station was fished within an intertidal slough on the southern edge of the facility riprap. The beach habitats at five of the seven stations were depositional zones of silt to silty sands likely created by the caissons that extend into the Arm, allowing fines to deposit on either side. The remaining two stations farthest north and south of the facility were not within its influence and were composed principally of sand, gravel, and cobble.

Juvenile salmonids were the dominant fish captured in both tow net and beach seine sets at Port McKenzie. Unlike the tow net transects, coho juveniles were most abundant along and near the pier. At least two coho life history trajectories were observed at the facility. Within the strong currents at the tow net sites on the pier, large coho, generally over 100 mm were captured. In beach seine sets in the nearshore, young-of-the-year coho under 40 mm were most often observed. We also observed (and captured with a hooligan dip net) many larger juvenile coho surface feeding near the boat launch adjacent to Ship Creek. We suspect these fish came from a recent release from the hatcheries. Juvenile sockeye and chum salmon were next in abundance at the Port MacKenzie facility, and were observed in relative equal numbers. Few Chinook or pink juveniles were observed. Juvenile salmon were observed at both the nearshore and offshore stations on the pier. Abundance may be more related to current strength and sustainability, rather than position in the nearshore. Further facility sampling will be conducted during the upcoming July sampling event to obtain additional data.

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MEMORANDUM

DATE: August 10, 2005

TO: Robin Reich, HDR, Alaska, Inc.

FROM: Jon Houghton, Jim Starkes, Pentec Environmental

RE: **Summary of July Sampling Activities – Knik Arm, Alaska**
12214-12

CC: Melinda Chambers; Kelly Barrett, Pentec Environmental

SUMMARY OF JULY SAMPLING ACTIVITIES

During the July sampling period, fish and invertebrate samples were collected by several methods over a 3-week period, as follows:

Date	Sampling Method	Stations
July 11, 13	120-ft Beach Seine	Beach Seine Stations 1, 2, 3, 7a, 10, 11a, 13, 14, 16
July 25	Intertidal Benthic Infauna	Beach Seine Stations 13, 16, 14, 7a, 10, PMN1
July 26, 28	Active Tow Net	Tow Net Transects 1, 2, 3, and 4. Stations 1, 2, 3, 4, and 5 at each transect.
July 12, 14, and 27	Facility Sampling	• Passive Tow Net at Stations PM00, PM01, PM02 on Port MacKenzie Pier • 30-ft beach seine at stations north and south of the Port MacKenzie Pier

120-FT BEACH SEINE

Beach seining occurred on July 11 and 13, 2005 at the six standard KABATA seining stations (Stations 7, 10, 11a, 13, 14, and 16) within outer Knik Arm, as well as at three additional stations (Station 1, 2, 3) within the inner Arm. Station 1, located near the mouth of Fire Creek and Station 3, near Eagle Bay are inner Arm stations sampled occasionally when flooding tides allow access and when whale monitors are available. Station 2 was a new station to the 2004-2005 study, first sampled in June, that had also been sampled in the

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1983 work. KA 2 is located between Goose Creek and Fish Creek and was sampled because it was the beach where seining was possible, nearest to a group of feeding beluga whales. Fish species observed in beach seine hauls are presented in Table 1.

Table 1 - Fish Species Observed during July 2005 Beach Seine Activities at Knik Arm

	Stations								
	1	2	3	7	10	11A	13	14	16
Chinook salmon									
Juvenile				X			X	X	X
Adult									
Coho salmon									
Juvenile	X	X		X	X	X	X	X	X
Adult									
Chum salmon									
Juvenile									
Adult									
Pink salmon									
Juvenile									
Adult						X			
Sockeye salmon									
Juvenile	X	X		X	X	X	X	X	X
Adult	X				X	X	X		X
Threespine stickleback	X	X		X	X	X	X	X	X
Ninespine stickleback	X	X		X				X	
Saffron cod									
Bering Cisco									X
Longfin smelt		X		X			X	X	X
Pacific herring									

Collectively, juvenile salmon were the dominant catch at most beach seine stations sampled in July; however, fewer juveniles were observed than during June sampling. Coho and sockeye juveniles were the dominant species with a few Chinook also present. No juvenile chum or pink salmon were observed. Longfin smelt were abundant at the outer most Arm stations near Point Woronzof and Point MacKenzie. Young-of-the-year threespine stickleback were also abundant, particularly at Station 10. Four Bering cisco were captured at Station 16. Saffron cod were notably absent during the July sampling period. Most of the few juvenile Chinook observed were preserved for possible otolith and/or stomach content analysis using funding from the Port of Anchorage.

For the first time in 2005, adult sockeye and pink salmon were taken in beach seine sets. Adult sockeye were relatively widespread in the Arm, captured at Stations 1, 2, 10, 11a, and 16. Adult pink salmon were taken at Station 11a. Stomach contents were examined in the field on a few specimens of sockeye; all were empty except for one, which contained two mysids. The mysids were quite small and it is not known if the specimen was actively feeding or if it swallowed the mysids unintentionally. Young-of-the-year mysids were quite abundant at some stations.

BENTHIC INFAUNA

Benthic infauna samples were collected on Juky 25 using a 0.009-square meter hand corer within the intertidal zone at Stations 13, 16, 14, 7a, 10, and PMN1 (Port MacKenzie). Samples were usually collected at the water's edge and the time of collection was recorded to determine tidal elevation. Because of the paucity of benthic invertebrates in Knik Arm sediments, some samples were collected farther up on the beach in areas of visual benthic activity (e.g., polychaete tracks on the mud surface). Once collected, each core sample was sieved through a 1-mm screen to uncover all invertebrates within the core sample. Two to three replicate samples were collected at each station.

Results of the benthic infauna survey were similar to those conducted in 2004. The only benthic invertebrates observed in Knik Arm intertidal sediments were polychaete worms. Densities were low ranging from 0 to 7 specimens per core sample. Most worms were observed in areas of fine silts to silty sands; very few were observed in gravel/cobble/sand habitats. Several specimens were preserved for laboratory identification.

ACTIVE TOW NET

The four offshore transects established in May were again sampled on July 26 and 28 using a tow net to determine the degree to which juvenile salmon and other species occupy offshore areas of the Arm. As in May and June, five equidistant stations were located along each transect and 5-minute tows were made at each to collect representative samples along offshore portions of the Arm.

Young-of-the-year threespine stickleback dominated catch at all tow net stations in July. Some sets yielded hundreds of young-of-the-year, most between 20 and 30 mm in length. Very few juvenile salmon were observed, unlike in June when salmonids dominated catch. Sockeye, coho, and Chinook were observed in low numbers. Ninespine stickleback also began to show at tow net stations, although in substantially lesser numbers than threespine. At several stations within Transects 3 and 4 several transparent larval herring and/or smelt were observed. Specimens were preserved for later laboratory identification.

FACILITY SAMPLING

On July 12, 14, and 27, intensive sampling with the tow net and 30-ft beach seine was conducted on and near the Port MacKenzie Pier facility to determine the relative abundance of juvenile salmonids as they migrate around the facility. Because the Port MacKenzie Pier is located near the narrowest segment of Knik Arm, tidal currents at the facility can be strong, but were quite variable throughout the tidal cycle. When tidal currents were moderate to strong, the tow net was hung and fished passively in the current at three locations on the pier. Fixed tow net sets were 5-minutes in duration and when possible, three replicate sets were made at each station. Station 00 was located nearest to shore along the pier caissons. Station 01 was located on the inner third of the pier, and Station 02 was located near the outer end of the pier. The tow net was fished on the south side of the pier during the ebbing tide and on the north side during a flooding tide.

Beaches adjacent to the pier facility were also sampled with a smaller 30-ft beach seine. This net was fished by deploying it perpendicular to shore, walking it upcurrent for length of approximately 100 ft., followed by pursing the net to the water's edge, forcing the catch into the cod end, situated in the center of the net. Three stations were located immediately north of the facility and three stations immediately south of the facility. The beach habitats at four of the six stations were depositional zones of silt to silty sands likely created by the caissons that extend into the Arm, allowing fines to deposit on either side. The remaining two stations farthest north and south of the facility were not within its influence and were composed principally of sand, gravel, and cobble.

As found in the active tow netting in offshore areas of the Arm, young-of-the-year threespine stickleback dominated catch with both the tow net hung off of the pier and 30 ft beach seine. However, a greater number of juvenile salmonids were present than was found in the offshore tow netting. Juvenile sockeye salmon were found in moderate numbers in fixed tow net samples at Stations 00 and 01 (nearest to the caissons and mid-pier). Coho were also observed in moderate numbers at these stations. A few Chinook salmon were captured at both fixed tow net and beach seine sites. One adult pink salmon and one adult coho salmon were captured during fixed tow net sampling in July. These fish were captured during periods of particularly intense currents, which appeared to have overcome their innate escape responses.

APPENDIX B
INVERTEBRATE CATCH IN BEACH SEINES
BY STATION AND TIME

APPENDIX B Invertebrate Data

Table B-1: Invertebrate CPUE by Month and Station Using the 120-Foot Beach Seine in 2004 and 2005

Station	Species	CPUE 2004					CPUE 2005				2004	2005	Total
		July	August	September	October	November	April	May	June	July	Total	Total	Overall
KA 1	*Crangon franciscorum*	0.0	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5	0.0	7.5
	Crangon nigricauda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Crangon spp.	0.0	168.5	0.0	0.0	0.0	0.0	0.0	7.0	0.0	168.5	7.0	175.5
	Lagunogammarus setosus	0.0	291.5	0.0	0.0	0.0	0.0	0.0	0.0	2.0	291.5	2.0	293.5
	Onisimus sp.	0.0	14.0	0.0	0.0	0.0	0.0	0.0	13.0	0.0	14.0	13.0	27.0
	Neomysis mercedis	0.0	31.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.5	0.0	31.5
	Neomysis rayii	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	6.0	0.5	6.0	6.5
	Saduria entomon	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.5	4.5	1.5	5.0	6.5
	Mysis litoralis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.0	50.5	0.0	74.5	74.5
	Total	**0.0**	**515.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**44.5**	**63.0**	**515.0**	**107.5**	**622.5**
KA 2	*Crangon franciscorum*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.0	158.5	0.0	189.5	189.5
	Crangon nigricauda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	53.0	7.0	0.0	60.0	60.0
	Crangon spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.5	9.5	0.0	54.0	54.0
	Lagunogammarus setosus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	62.0	0.0	62.5	62.5
	Onisimus limnicola	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	17.5	0.0	18.0	18.0
	Neomysis mercedis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0	14.0	0.0	28.0	28.0
	Neomysis rayii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0	0.0	0.0	14.0	14.0
	Total	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**157.5**	**268.5**	**0.0**	**426.0**	**426.0**
KA 3	*Crangon franciscorum*	0.0	10.5	0.0	0.0	0.0	0.0	0.0	129.0	110.5	10.5	239.5	250.0
	Crangon nigricauda	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5
	Crangon spp.	0.0	225.5	0.0	0.0	0.0	0.0	5.0	7.0	0.0	225.5	12.0	237.5
	Lagunogammarus setosus	0.0	74.5	0.0	0.0	0.0	0.0	0.0	0.0	15.0	74.5	15.0	89.5
	Onisimus sp.	0.0	1.0	0.0	0.0	0.0	0.0	0.0	2.5	22.5	1.0	25.0	26.0
	Neomysis mercedis	0.0	9.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.5	0.0	9.5
	Neomysis rayii	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5	0.0	1.0	1.0
	Saduria entomon	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.5	0.5
	Neanthes limnicola	0.0	0.0	0.0	0.0	0.0	0.0	4.5	1.5	6.5	0.0	12.5	12.5
	Total	**0.0**	**321.5**	**0.0**	**0.0**	**0.0**	**0.0**	**10.5**	**140.0**	**155.0**	**321.5**	**305.5**	**627.0**
KA 5	*Crangon franciscorum*	0.0	0.0	0.0	0.0	0.5	0.0	14.5	0.0	0.0	0.5	14.5	15.0
	Crangon nigricauda	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	10.0	10.0
	Lagunogammarus setosus	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	2.0	2.0
	Onisimus sp.	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	1.0
	Neomysis mercedis	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	1.5	1.5
	Neomysis rayii	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.5	0.5
	Neanthes limnicola	0.0	0.0	0.0	0.0	0.5	0.0	4.5	0.0	0.0	0.5	4.5	5.0
	Total	**0.0**	**0.0**	**0.0**	**0.0**	**1.0**	**0.0**	**34.0**	**0.0**	**0.0**	**1.0**	**34.0**	**35.0**
KA 6	*Crangon franciscorum*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Onisimus sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.5	0.0	0.0	9.5	9.5
	Neomysis mercedis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Neomysis rayii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.0	0.0	0.0	28.0	28.0
	Neanthes limnicola	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.5	0.0	0.0	40.5	40.5
	Terrestrial insect	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.5	0.5
	Total	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**78.5**	**0.0**	**0.0**	**78.5**	**78.5**

APPENDIX B Invertebrate Data

Table B-1: Invertebrate CPUE by Month and Station Using the 120-Foot Beach Seine in 2004 and 2005

Station	Species	CPUE 2004					CPUE 2005				2004	2005	Total
		July	August	September	October	November	April	May	June	July	Total	Total	Overall
KA 7	*Crangon franciscorum*	0.0	5.5	0.0	0.0	0.0	0.0	2.5	39.8	0.0	5.5	42.3	47.8
	Crangon nigricauda	0.0	5.0	0.0	0.0	0.0	0.0	5.0	125.8	54.0	5.0	184.8	189.8
	Crangon spp.	0.0	267.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	267.5	0.0	267.5
	Lagunogammarus setosus	0.0	81.0	0.0	0.0	4.5	0.0	0.0	0.0	98.0	85.5	98.0	183.5
	Onisimus sp.	0.0	7.5	0.0	0.0	0.0	0.0	0.0	1.3	31.0	7.5	32.3	39.8
	Neomysis mercedis	0.0	7.5	0.0	0.0	0.0	0.0	2.0	0.3	0.0	7.5	2.3	9.8
	Neomysis rayii	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.5	0.3	0.8
	Neomysis kadiakensis	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	2.5	0.0	2.5
	Mysid, unid.	0.0	0.0	0.0	0.0	0.5	0.0	6.0	0.8	18.5	0.5	25.3	25.8
	Saduria entomon	0.0	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	0.0	5.5
	Neanthes limnicola	0.0	0.5	0.0	0.0	3.5	0.0	0.5	0.0	0.0	4.0	0.5	4.5
	Terrestrial insect	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.5	0.5
	Total	**0.0**	**380.5**	**0.0**	**0.0**	**11.0**	**0.0**	**16.0**	**168.5**	**201.5**	**391.5**	**386.0**	**777.5**
KA 7A	*Crangon franciscorum*	46.5	13.0	450.5	441.5	0.0	0.0	2.7	0.0	202.5	951.5	205.2	1156.7
	Crangon nigricauda	17.5	2.5	14.8	4.0	0.0	0.5	14.0	0.0	3.0	38.8	17.5	56.3
	Crangon spp.	200.5	173.0	0.0	0.3	0.0	0.0	4.3	0.0	4.0	373.8	8.3	382.1
	Lagunogammarus setosus	2.5	10.0	5.0	0.3	7.5	0.0	0.2	0.0	23.5	25.3	23.7	49.0
	Onisimus spp.	1.5	2.5	3.0	1.0	0.5	0.0	0.1	0.0	3.5	8.5	3.6	12.1
	Neomysis mercedis	16.0	9.5	8.0	1.5	0.0	6.5	11.6	0.0	1.0	35.0	19.1	54.1
	Neomysis rayii	0.0	0.0	1.3	2.6	0.0	0.5	0.2	0.0	0.0	3.9	0.7	4.6
	Saduria entoman	0.5	2.5	3.5	0.0	0.0	0.0	0.1	0.0	0.0	6.5	0.1	6.6
	Neanthes limnicola	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
	Terrestrial insect	0.0	0.0	0.0	0.3	0.0	0.0	0.4	0.0	0.0	0.3	0.4	0.7
	Total	**285.0**	**213.0**	**486.1**	**451.4**	**9.0**	**7.5**	**33.6**	**0.0**	**237.5**	**1444.4**	**278.6**	**1723.0**
KA 7B	*Crangon franciscorum*	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	4.5
	Crangon nigricauda	16.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	0.0	16.0
	Neomysis mercedis	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	1.5
	Lagunogammarus setosus	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
	Onisimus sp.	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
	Saduria entomon	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5
	Total	**24.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**24.5**	**0.0**	**24.5**
KA 10	*Crangon franciscorum*	6.5	6.0	248.8	285.8	0.0	0.0	0.0	30.3	63.0	547.0	93.3	640.3
	Crangon nigricauda	3.8	3.5	22.8	4.0	0.0	3.6	59.9	91.7	40.5	34.0	195.7	229.7
	Crangon spp.	144.5	71.5	0.0	0.0	0.0	0.0	3.3	4.3	16.0	216.0	23.7	239.7
	Lagunogammarus setosus	2.3	12.0	14.3	4.0	1.0	0.0	0.0	0.0	154.5	33.5	154.5	188.0
	Onisimus spp.	0.5	1.5	7.0	2.3	0.0	0.0	0.1	3.0	149.5	11.3	152.6	163.9
	Neomysis mercedis	8.0	25.0	14.5	13.5	0.0	9.2	0.1	0.3	0.0	61.0	9.6	70.6
	Neomysis rayii	0.0	0.0	2.1	5.5	0.0	0.0	0.4	3.7	0.0	7.6	4.1	11.7
	Mysis litoralis	0.0	0.0	2.0	0.0	0.0	0.8	2.9	0.0	1.0	2.0	4.7	6.7
	Saduria entomon	0.0	0.0	0.3	0.0	0.0	1.6	0.0	0.3	2.0	0.3	3.9	4.2
	Neanthes limnicola	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.5	0.0	0.6	0.6
	Terrestrial insect	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.4	0.4
	Total	**165.5**	**119.5**	**311.6**	**315.0**	**1.0**	**15.2**	**67.0**	**133.8**	**427.1**	**912.6**	**643.1**	**1555.7**

APPENDIX B Invertebrate Data

Table B-1: Invertebrate CPUE by Month and Station Using the 120-Foot Beach Seine in 2004 and 2005

Station	Species	CPUE 2004					CPUE 2005				2004	2005	Total
		July	August	September	October	November	April	May	June	July	Total	Total	Overall
KA 10A	*Neomysis* spp.	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.5	0.0	0.5
	Total	**0.0**	**0.0**	**0.0**	**0.0**	**0.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.5**	**0.0**	**0.5**
KA 11	*Crangon franciscorum*	11.0	8.5	113.5	140.5	1.8	7.6	202.3	0.0	0.0	275.3	209.9	485.2
	Crangon nigricauda	4.5	4.0	4.5	3.8	0.3	0.0	0.0	0.0	0.0	17.0	0.0	17.0
	Crangon spp.	173.3	66.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	239.3	0.0	239.3
	Lagunogammarus setosus	11.8	15.5	24.8	19.5	5.3	0.6	4.7	0.0	0.0	76.8	5.3	82.0
	Onisimus spp.	0.3	1.5	0.8	0.8	3.5	0.5	1.0	0.0	0.0	6.8	1.5	8.3
	Neomysis kadiakensis	0.0	0.0	0.0	7.5	20.5	0.0	0.0	0.0	0.0	28.0	0.0	28.0
	Neomysis mercedis	73.5	9.5	8.8	10.3	0.0	0.0	0.0	0.0	0.0	102.0	0.0	102.0
	Neomysis rayii	0.0	0.0	0.3	2.5	1.0	0.0	0.0	0.0	0.0	3.8	0.0	3.8
	Mysis litoralis	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	1.5
	Mysid, unid.	0.0	0.0	0.0	1.0	0.5	0.0	0.0	0.0	0.0	1.5	0.0	1.5
	Saduria entomon	0.0	0.5	0.8	0.0	0.0	0.5	27.7	0.0	0.0	1.3	28.2	29.4
	Argeia pugettensis	0.0	0.0	0.0	0.0	0.0	0.4	0.3	0.2	0.4	0.0	1.3	1.3
	Neanthes limnicola	0.0	0.0	0.0	0.0	0.3	1.1	1.7	0.0	0.0	0.3	2.8	3.0
	Total	**274.3**	**105.5**	**154.8**	**185.8**	**33.0**	**10.7**	**237.6**	**0.2**	**0.4**	**753.3**	**248.9**	**1002.2**
KA 11A	*Crangon franciscorum*	0.5	0.0	29.0	38.5	0.0	13.5	0.0	0.0	0.0	68.0	13.5	81.5
	Crangon alaskensis	0.5	0.0	0.5	0.2	0.0	0.0	0.0	0.0	0.0	1.2	0.0	1.2
	Crangon spp.	11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.7	11.0	12.7	23.7
	Neomysis rayii	0.0	0.0	0.0	10.8	17.5	0.0	0.0	0.0	0.0	28.3	0.0	28.3
	Neomysis mercedis	3.0	0.0	4.5	3.3	0.5	1.5	0.0	0.0	0.0	11.3	1.5	12.8
	Mysis litoralis	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.3	1.0	0.3	1.3
	Mysid, unid.	0.0	0.0	0.5	0.2	0.5	0.0	0.0	0.0	0.0	1.2	0.0	1.2
	Lagunogammarus setosus	8.5	0.0	5.5	10.7	0.5	0.0	0.0	0.0	170.7	25.2	170.7	195.8
	Neanthes spp.	0.0	0.0	1.0	0.2	0.0	0.0	0.0	0.0	213.7	1.2	213.7	214.8
	Saduria entomon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3	0.3
	Terrestrial insect	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Macoma balthica	0.0	0.0	0.0	0.0	0.0	16.5	0.0	0.0	12.3	0.0	28.8	28.8
	Total	**23.5**	**0.0**	**42.0**	**63.8**	**19.0**	**31.5**	**0.0**	**0.0**	**410.0**	**148.3**	**441.5**	**589.8**
KA 13	*Crangon franciscorum*	11.5	0.0	105.3	150.0	0.0	0.0	0.0	0.0	0.0	266.8	0.0	266.8
	Crangon nigricauda	11.0	1.0	6.3	8.5	0.0	0.0	0.0	0.0	0.0	26.8	0.0	26.8
	Crangon spp.	99.5	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	139.5	0.0	139.5
	Lagunogammarus setosus	3.5	5.0	16.0	9.5	0.0	0.0	0.0	0.0	0.0	34.0	0.0	34.0
	Onisimus sp.	1.0	1.5	3.3	0.0	0.0	0.0	0.0	0.0	0.0	5.8	0.0	5.8
	Neomysis kadiakensis	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	2.5	0.0	2.5
	Neomysis mercedis	13.5	9.0	2.0	1.5	0.0	0.0	0.0	0.0	0.0	26.0	0.0	26.0
	Neomysis rayii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mysis litoralis	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0
	Saduria entomon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Littorina sitkana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Terrestrial insect	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**140.0**	**56.5**	**134.8**	**172.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**503.3**	**0.0**	**503.3**

APPENDIX B Invertebrate Data

Table B-1: Invertebrate CPUE by Month and Station Using the 120-Foot Beach Seine in 2004 and 2005

Station	Species	CPUE 2004					CPUE 2005				2004	2005	Total
		July	August	September	October	November	April	May	June	July	Total	Total	Overall
KA 14	*Crangon franciscorum*	4.3	27.5	24.3	90.0	0.0	26.5	0.0	0.0	0.0	146.0	26.5	172.5
	Crangon nigricauda	3.0	0.5	2.3	1.0	0.0	2.0	61.8	37.0	0.0	6.8	100.8	107.6
	Crangon spp.	47.8	1.5	0.3	0.5	0.0	0.0	0.0	0.0	0.0	50.0	0.0	50.0
	Lagunogammarus setosus	5.3	8.0	6.0	1.8	2.5	0.0	44.5	0.0	2.5	23.5	47.0	70.5
	Onisimus sp.	1.8	0.5	2.5	7.0	2.0	0.3	27.9	0.0	0.0	13.8	28.2	41.9
	Neomysis mercedis	42.0	10.5	6.8	1.5	0.0	0.0	0.0	0.0	0.0	60.8	0.0	60.8
	Neomysis rayii	0.0	0.0	0.0	28.1	0.0	0.0	0.0	2.5	0.0	28.1	2.5	30.6
	Mysis litoralis	0.0	0.0	1.5	0.3	12.0	0.0	5.5	0.0	0.0	13.8	5.5	19.3
	Mysid, unid.	0.0	0.0	4.0	0.0	2.5	0.0	0.0	0.0	0.0	6.5	0.0	6.5
	Saduria entomon	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3
	Neanthes limnicola	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
	Saduria entomon	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3
	Terrestrial insect	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.4	0.4
	Total	**104.3**	**48.5**	**47.5**	**130.3**	**20.0**	**28.8**	**139.9**	**39.6**	**2.6**	**350.6**	**210.8**	**561.4**
KA 16	*Crangon franciscorum*	7.5	0.5	15.3	2.5	1.5	2.7	142.8	53.0	2.3	27.3	200.8	228.0
	Crangon nigricauda	14.0	2.5	4.0	89.5	0.5	0.0	0.0	19.0	21.5	110.5	40.5	151.0
	Crangon spp.	132.0	22.0	0.0	0.5	0.0	0.0	0.0	0.0	16.0	154.5	16.0	170.5
	Lagunogammarus setosus	1.0	5.5	2.5	3.0	10.5	0.0	0.0	0.0	0.0	22.5	0.0	22.5
	Onisimus sp.	0.0	4.0	7.0	0.5	5.5	0.0	0.0	0.0	0.0	17.0	0.0	17.0
	Neomysis rayii	0.0	0.0	1.5	1.0	6.0	0.0	0.0	0.0	0.0	8.5	0.0	8.5
	Neomysis mercedis	81.5	0.0	1.0	0.5	0.0	0.5	0.0	0.0	0.0	83.0	0.5	83.5
	Mysid, unid.	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	2.5	0.0	2.5
	Terrestrial insect	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	3.4	0.0	3.8	3.8
	Neanthes limnicola	0.0	0.0	0.0	0.0	5.0	0.0	0.0	1.0	0.0	5.0	1.0	6.0
	Total	**236.0**	**34.5**	**31.3**	**97.5**	**31.5**	**3.2**	**142.8**	**73.3**	**43.2**	**430.8**	**262.5**	**693.3**
KA 13N	*Crangon franciscorum*	0.0	0.0	0.0	0.0	0.0	93.0	0.0	0.0	0.0	0.0	93.0	93.0
	Crangon nigricauda	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.8	0.8
	Lagunogammarus setosus	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.5	0.5
	Onisimus sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mysis litoralis	0.0	0.0	0.0	0.0	0.0	97.3	0.0	0.0	0.0	0.0	97.3	97.3
	Saduria entomon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Crangon franciscorum	0.0	0.0	0.0	0.0	0.0	51.0	0.0	0.0	0.0	0.0	51.0	51.0
	Total	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**242.7**	**0.0**	**0.0**	**0.0**	**0.0**	**242.7**	**242.7**
KA 13S	*Crangon nigricauda*	0.0	0.0	0.0	0.0	0.0	5.8	0.0	0.0	0.0	0.0	5.8	5.8
	Lagunogammarus setosus	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.7	0.7
	Onisimus sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Neanthes limnicola	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**6.4**	**0.0**	**0.0**	**0.0**	**0.0**	**6.4**	**6.4**
	Grand Total	**978.8**	**1689.0**	**1053.2**	**1230.0**	**93.0**	**335.2**	**443.9**	**835.8**	**1808.3**	**5043.9**	**3423.2**	**8467.1**

Appendix B (cont.)

Table B-2: Invertebrate Catch by Station in 120-Foot Beach Seine Sampling

			Stations										
Species	**Total Catch**	**Overall %**	**KA 1**	**KA 2**	**KA 3**	**KA 5**	**KA 6**	**KA 7**	**KA 10**	**KA 11**	**KA 13**	**KA 14**	**KA 16**
Crangon franciscorum	5329	47.6	14	120	24	20	81	769	913	758	1255	451	924
Crangon nigricauda	513	4.6	0	108	0	4	0	51	75	107	63	73	32
Crangon sp.	1541	13.8	4	125	30	0	0	245	309	513	80	94	141
Lagunogammarus setosus	1440	12.9	149	56	25	9	0	196	32	154	799	14	6
Onisimus sp.	1	1.8	0	0	0	0	0	0	0	0	1	0	0
Saduria entomon	1	1.5	0	0	0	0	0	0	0	1	0	0	0
Neomysis mercedis	24	1.1	12	0	0	0	0	1	2	3	5	1	0
Neomysis rayii	79	15.7	0	0	2	3	1	9	48	13	2	0	1
Mysis litoralis	128	0.2	0	28	0	1	56	1	15	3	2	10	12
Neanthes sp.	1753	0.7	26	36	50	2	23	75	309	673	152	297	110
Littorina sitkana	203	0.0	10	6	10	4	1	6	13	104	32	17	0
Macoma baltica	1	0.0	0	0	0	0	0	0	0	1	0	0	0
Terrestrial insect	12	0.1	0	0	1	0	2	3	0	2	2	1	1
Total Number of Sets	169	**100**	**2**	**0**	**1**	**0**	**0**	**42**	**5**	**32**	**64**	**22**	**1**
Grand Total	11194	**n/a**	**217**	**479**	**143**	**43**	**164**	**1398**	**1721**	**2364**	**2457**	**980**	**1228**

Table B-3 Invertebrate CPUE by Station in 120-Foot Beach Seine Sampling

		Stations										
Species	**Overall**	**KA 1**	**KA 2**	**KA 3**	**KA 5**	**KA 6**	**KA 7**	**KA 10**	**KA 11**	**KA 13**	**KA 14**	**KA 16**
Crangon franciscorum	31.5	3.50	30.00	4.00	10.00	40.50	29.58	48.05	16.13	33.92	26.53	61.60
Crangon nigricauda	3.0	0.00	27.00	0.00	2.00	0.00	1.96	3.95	2.28	1.70	4.29	2.13
Crangon sp.	9.1	1.00	31.25	5.00	0.00	0.00	9.42	16.26	10.91	2.16	5.53	9.40
Lagunogammarus setosus	8.5	37.25	14.00	4.17	4.50	0.00	7.54	1.68	3.28	21.59	0.82	0.40
Onisimus sp.	0.0	2.50	1.50	1.67	2.00	0.50	0.23	0.68	2.21	0.86	1.00	0.00
Saduria entomon	0.0	0.50	0.00	0.17	0.00	0.00	1.62	0.26	0.68	1.73	1.29	0.07
Neomysis mercedis	0.1	0.00	7.00	0.00	0.50	28.00	0.04	0.79	0.06	0.05	0.59	0.80
Neomysis rayii	0.5	6.50	9.00	8.33	1.00	11.50	2.88	16.26	14.32	4.11	17.47	7.33
Mysis litoralis	0.8	3.00	0.00	0.00	0.00	0.00	0.04	0.11	0.06	0.14	0.06	0.00
Neanthes sp.	10.4	0.00	0.00	0.33	1.50	0.50	0.35	2.53	0.28	0.05	0.00	0.07
Littorina sitkana	1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
Macoma baltica	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Terrestrial insect	0.1	0.00	0.00	0.17	0.00	1.00	0.12	0.00	0.06	0.05	0.06	0.07
Grand Total	**66.2**	**54.25**	**119.75**	**23.83**	**21.50**	**82.00**	**53.77**	**90.58**	**50.30**	**66.41**	**57.65**	**81.87**

Appendix B (cont.)

Table B-4: Statistical Analyses of Invertebrates Sampled with the 120-Foot Beach Seine

Variable	Taxon	Statistic	df	Significance
		Chi-Square		
date	Crangonids	28.37	3	**0.000**
	Amphipoda	7.22	3	0.065
	Mysidae	50.77	3	**0.000**
	Neanthes	5.78	3	0.123
	Isopoda	7.82	3	**0.050**
	Terrestrial Inverts	3.27	3	0.352
	All Species	17.97	3	**0.000**
Station	Crangonids	8.60	11	0.658
	Amphipoda	36.15	11	**0.000**
	Mysidae	14.18	11	0.223
	Neanthes	20.01	11	**0.045**
	Isopoda	2.67	11	0.994
	Terrestrial Inverts	14.94	11	0.185
	All Species	3.69	11	0.978
Tide	Crangonids	9.64	2	**0.008**
	Amphipoda	2.79	2	0.248
	Mysidae	15.18	2	**0.001**
	Neanthes	2.29	2	0.319
	Isopoda	0.71	2	0.699
	Terrestrial Inverts	0.93	2	0.628
	All Species	9.22	2	**0.010**

Table B-5: Statistical Analyses of Invertebrates Sampled with the Surface Tow Net

Variable	Taxon	Statistic	df	Significance
Month		**Chi-Square**		
	Crangonids	24.12	2	**0.000**
	Amphipoda	1.22	2	0.544
	Mysidae	34.82	2	**0.000**
	Isopoda	5.11	2	0.078
	Terrestrial Inverts	4.70	2	0.096
	All Species	7.26	2	**0.027**
Transect		**Chi-Square**		
	Crangonids	10.23	5	0.069
	Amphipoda	9.57	5	0.088
	Mysidae	4.48	5	0.483
	Isopoda	9.52	5	0.090
	Terrestrial Inverts	7.42	5	0.191
	All Species	10.66	5	0.058
Tide		**Chi-Square**		
	Crangonids	8.53	3	**0.036**
	Amphipoda	0.15	3	0.986
	Mysidae	0.84	3	0.841
	Isopoda	4.92	3	0.178
	Terrestrial Inverts	3.03	3	0.388
	All Species	5.43	3	0.143
Station		**Mann-Whitney**	**Z**	
(Nearshore v. Offshore)	Crangonids	520.50	-0.22	0.829
	Amphipoda	515.00	-0.29	0.775
	Mysidae	497.00	-0.52	0.606
	Isopoda	525.00	-0.21	0.837
	Terrestrial Inverts	507.00	-1.09	0.275
	All Species	537.00	-0.01	0.995

Table B-6: Statistical Analyses of Invertebrates Sampled with the Fixed Tow Net

Variable	Taxon	Statistic		Significance
Month		**Mann-Whitney**	**Z-Value**	
	Crangonids	67.00	-0.28	0.777
	Amphipoda	40.00	-1.81	0.070
	Mysidae	12.50	-3.37	**0.001**
	Neanthes	67.50	-0.75	0.453
	Terrestrial Inverts	67.50	-0.75	0.453
	All Species	32.00	-2.26	**0.024**
Station		**Chi-Square**	**df**	
	Crangonids	3.60	2	0.165
	Amphipoda	3.81	2	0.148
	Mysidae	6.49	2	**0.039**
	Neanthes	1.27	2	0.529
	Terrestrial Inverts	1.27	2	0.529
	All Species	4.73	2	0.094
Tide		**Chi-Square**	**df**	
	Crangonids	1.42	3	0.700
	Amphipoda	0.82	3	0.845
	Mysidae	2.10	3	0.551
	Neanthes	0.92	3	0.820
	Terrestrial Inverts	0.92	3	0.820
	All Species	3.31	3	0.346

APPENDIX C
SPECIES AND PERCENT OF CATCH FOR EACH GEAR TYPE AND YEAR

Table C-1: Summary of CPUE by all Gear Types During June and July Sampling

Species	120 foot seine		30 foot seine		Fixed Tow Net		Tow Net	
	June	July	June	July	June	July	June	July
Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*)	3.24	0.64	0.06	0.11	0.26	0.36	0.40	0.25
Adult Chinook Salmon (*O. tshawytscha*)	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Juvenile Chum Salmon (*O. keta*)	1.90	0.00	0.47	0.11	1.82	0.04	2.52	0.00
Adult Chum Salmon (*O. keta*)	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Juvenile Coho Salmon (*O. kisutch*)	2.34	3.92	4.56	0.96	3.11	0.52	0.52	0.10
Adult Coho Salmon (*O. kisutch*)	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00
Juvenile Pink Salmon (*O. gorbuscha*)	0.03	0.04	0.13	0.00	0.11	0.00	0.72	0.00
Adult Pink Salmon (*O. gorbuscha*)	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00
Juvenile Sockeye Salmon *(O. nerka)*	3.62	2.44	3.06	0.86	2.66	2.20	6.68	0.45
Adult Sockeye Salmon *(O. nerka)*	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00
Rainbow Trout (*O. mykiss*)	0.00	0.16	0.00	0.04	0.00	0.00	0.00	0.00
Dolly Varden (*Salvelinus malma*)	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Bering Cisco (*Coregonus laurettae*)	0.00	0.16	0.00	0.32	0.00	0.28	0.00	0.00
Longfin Smelt (*Spirinchus thaleichthys*)	6.14	3.08	3.50	0.14	0.08	0.04	0.04	0.20
Pacific Herring (*Clupea pallasi*)	0.17	0.04	0.00	0.04	0.00	0.00	0.08	1.35
Saffron Cod (*Eleginus gracilis*)	0.24	0.00	0.00	0.07	0.00	0.00	0.04	0.05
Ringtail Snailfish (*Liparis rutteri*)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Threespine Stickleback (*Gasterosteus aculeatus*)	1.90	6.64	2.91	7.29	0.11	11.64	0.12	76.45
Ninespine Stickleback (*Pungitius pungitius*)	0.07	0.84	0.06	0.57	0.05	0.36	0.00	1.40
Pacific Staghorn Sculpin (*Leptocottus armatus*)	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Starry Flounder (Platichthys stellatus)	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Eulachon (*Thaleichthys pacificus*)	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.05
Tomcod (*Microgadus proximus)*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Walleye Pollock (*Theragra chalcogramma*)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unidentified Flatfish	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00
larval fish (unid'd)	0.00	0.00	0.00	0.04	0.00	0.04	0.00	1.25
Grand Total	**19.69**	**18.84**	**27.19**	**10.54**	**8.26**	**17.92**	**11.20**	**81.70**
All Juvenile Salmonids	**11.14**	**7.04**	**8.28**	**1.96**	**7.95**	**3.12**	**10.84**	**0.80**
Total Number of Sets	**29**	**29**	**32**	**28**	**38**	**25**	**25**	**20**

Table C-2 Total Catch by each Gear Types During June and July Sampling

Species	Beach Seine		30-Foot Beach Seine		Fixed Tow Net		Tow Net	
	June	July	June	July	June	July	June	July
Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*)	94	16	2	3	10	9	10	5
Adult Chinook Salmon (*O. tshawytscha*)	1	0	0	0	0	0	0	0
Juvenile Chum Salmon (*O. keta*)	55	0	15	3	69	1	63	0
Adult Chum Salmon (*O. keta*)	0	1	0	0	0	0	0	0
Juvenile Coho Salmon (*O. kisutch*)	68	98	146	27	118	13	13	2
Adult Coho Salmon (*O. kisutch*)	0	4	0	0	0	0	0	0
Juvenile Pink Salmon (*O. gorbuscha*)	1	1	4	0	4	0	18	0
Adult Pink Salmon (*O. gorbuscha*)	0	4	0	0	0	0	0	0
Juvenile Sockeye Salmon *(O. nerka)*	105	61	98	24	101	55	167	9
Adult Sockeye Salmon *(O. nerka)*	0	10	0	0	0	0	0	0
Rainbow Trout (*O. mykiss*)	0	4	0	1	0	0	0	0
Dolly Varden (*Salvelinus malma*)	0	1	0	0	0	0	0	0
Bering Cisco (*Coregonus laurettae*)	0	4	0	9	0	7	0	0
Longfin Smelt (*Spirinchus thaleichthys*)	178	77	112	4	3	1	1	4
Pacific Herring (*Clupea pallasi*)	5	1	0	1	0	0	2	27
Saffron Cod (*Eleginus gracilis*)	7	0	0	2	0	0	1	1
Ringtail Snailfish (*Liparis rutteri*)	0	2	0	0	0	0	0	0
Threespine Stickleback (*Gasterosteus aculeatus*)	55	166	93	204	4	291	3	1529
Ninespine Stickleback (*Pungitius pungitius*)	2	21	2	16	2	9	0	0
Pacific Staghorn Sculpin (*Leptocottus armatus*)	0	0	0	1	0	0	0	0
Starry Flounder (Platichthys stellatus)	0	0	0	1	0	0	0	0
Eulachon (*Thaleichthys pacificus*)	0	0	0	0	0	0	1	1
Tomcod (*Microgadus proximus)*	0	0	0	0	0	0	0	0
Walleye Pollock (*Theragra chalcogramma*)	0	0	0	0	0	0	0	25
Unidentified Flatfish	0	0	0	0	0	0	0	28
larval fish (unid'd)	0	0	0	1	0	1	1	0
Grand Total	571	471	472	297	311	387	280	1631
All Juvenile Salmonids	323	176	265	57	302	78	271	16

Table C-3 Summary of Catch and Percent of Total Catch of Each Species, by Each Gear Type During June and .

Species	Beach Seine Combined	Beach Seine % Total	30-Foot Beach Seine Combined	30-Foot Beach Seine % Total	Fixed Tow Net Combined	Fixed Tow Net % Total	Tow Net Combined	Tow Net % Total
Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*)	110	10.56	5	0.01	19	2.72	15	0.78
Adult Chinook Salmon (*O. tshawytscha*)	1	0.10	0	0.00	0	0.00	0	0.00
Juvenile Chum Salmon (*O. keta*)	10	5.28	18	0.02	70	10.03	63	3.30
Adult Chum Salmon (*O. keta*)	1	0.10	0	0.00	0	0.00	0	0.00
Juvenile Coho Salmon (*O. kisutch*)	55	15.93	173	0.22	131	18.77	15	0.78
Adult Coho Salmon (*O. kisutch*)	4	0.38	0	0.00	0	0.00	0	0.00
Juvenile Pink Salmon (*O. gorbuscha*)	166	0.19	4	0.01	4	0.57	18	0.94
Adult Pink Salmon (*O. gorbuscha*)	4	0.38	0	0.00	0	0.00	0	0.00
Juvenile Sockeye Salmon *(O. nerka)*	2	15.93	122	0.16	156	22.35	176	9.21
Adult Sockeye Salmon *(O. nerka)*	4	0.96	0	0.00	0	0.00	0	0.00
Rainbow Trout (*O. mykiss*)	1	0.38	1	0.00	0	0.00	0	0.00
Dolly Varden (*Salvelinus malma*)	4	0.10	0	0.00	0	0.00	0	0.00
Bering Cisco (*Coregonus laurettae*)	0	0.38	9	0.01	7	1.00	0	0.00
Longfin Smelt (*Spirinchus thaleichthys*)	166	24.47	116	0.15	4	0.57	5	0.26
Pacific Herring (*Clupea pallasi*)	2	0.58	1	0.00	0	0.00	29	1.52
Saffron Cod (*Eleginus gracilis*)	255	0.67	2	0.00	0	0.00	2	0.10
Ringtail Snailfish (*Liparis rutteri*)	23	0.19	0	0.00	0	0.00	0	0.00
Threespine Stickleback (*Gasterosteus aculeatus*)	0	21.21	297	0.39	295	42.26	1532	80.17
Ninespine Stickleback (*Pungitius pungitius*)	221	2.21	18	0.02	11	1.58	0	0.00
Pacific Staghorn Sculpin (*Leptocottus armatus*)	7	0.00	1	0.00	0	0.00	0	0.00
Starry Flounder (Platichthys stellatus)	0	0.00	1	0.00	0	0.00	0	0.00
Eulachon (*Thaleichthys pacificus*)	6	0.00	0	0.00	0	0.00	2	0.10
Tomcod (*Microgadus proximus)*	0	0.00	0	0.00	0	0.00	0	0.00
Walleye Pollock (*Theragra chalcogramma*)	0	0.00	0	0.00	0	0.00	25	1.31
Unidentified Flatfish	0	0.00	0	0.00	0	0.00	28	1.47
larval fish (unid'd)	0	0.00	1	0.00	1	0.14	1	0.05
Grand Total	1042.0	100.0	769.0	100.0	698.0	100.0	1911.0	100.0
All Juvenile Salmonids	343.0	47.9	322.0	0.4	380.0	54.4	287.0	15.0